Mesocosm User Manual

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Contents

Chapter 1

Summary

This manual describes the design, operation, and maintenance of the mesocosm aquaria, located in the loading bay between Citrus Hall and Eucalyptus Hall at California State University, Northridge, funded and operated by Dr. Nyssa Silbiger.

Chapter 2

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Chapter 3

System Details

Contents
- **Aquaria System**
- **Filtration and Recirculation System**
- **System Operational Sequence**
- **Apex Connection Series**
- **EB832 Outlet Connections**

Aquaria System Component List

- Experimental Tanks (21.25” x 12.5” x 13.5”H) - Per tank:
- 1 Submersible powerhead pump (Hydor Nano Koralia 240 powerhead)
- 1 200 W Heater (Hydor aquarium heater)
- 1 Light (Halo Basic M-110)
- 1 Temperature probe (Apex)
- 1 pH probe (Apex)
- 1 Solenoid valve for pH (Apex)
- 3 Flow sensors (Apex, FS-25 1/4” fitting, flow rates from 3-12 GPH (12-45 LPH))
- 1 Main Supply line: “N”
- 1 Solenoid Supply line: “S”
- 1 Drain line: “D”
- 1 Gate valve (solenoid for water inflow)
- 1 VDM (Apex Variable Dimming Module, 1 unit for 4 tanks)
- 1 FMM (Apex Fluid Metering Module)
- 1 PM1 (Apex Probe Module 1)
- 1 Base Unit (Apex processing unit, 1 unit for 4 tanks)

- 1 EB832 (Apex 8-outlet EnergyBar, 1 unit for 2 tanks)
- 1 CO2 regulator valve (Tunze pH Controller Set, pressure reducing valve 7077/3)
- 1 Industrial Grade Carbon Dioxide, 50 pound cylinder

Filtration and Recirculation System Component List

- Sump (66.25" x 31.5" x 21"H)
- Chiller (AquaLogic Multi-Temp and Titan Series)
- Heat Pump (AquaLogic Multi-Temp and Titan Series)
- PM1 (Apex Probe Module 1)
- PhosBan chemical filter (PhosBan Reactor 550)
- Water pump (PerformancePro Cascade pump)
- UV Sterilizer (Comet Series 95 Watt Lamp)
- CO2 Scrubber (4 outflow tubing ports)
- Airstones (4 units)
- Carbon filter cells (3 units, CF28AC,28in, ActC)
- Mesh filter (8 units, Matala Filter Media, interchanged 4 Blue high density and 4 Black low density sheets)

System Operational Sequence

- This is a closed loop system where water from each individual tank will recirculate back to a main holding reservoir (sump).
- Normal High Tide operating water level is approximately 12.5"H for a total water volume of 14.37 gal per tank (287.4 gal total for the 20-tank-system).
- Normal Low Tide operating water level is approximately 4"H for a total water volume of 4.60 gal per tank (92.0 gal total for the 20-tank-system).
- Excess water volume to sump at low tide is 9.77 gal per tank (195.4 gal total for the 20-tank-system).
- Normal sump operating water level is 7" water in the filter cell compartment, which has an approximate volume of 82.32 gal. Sump freeboard volume is 107.39 gal.
- Aquaria drain line is in line with a 30 gal sump pump, which will draw water from the aquaria drain line and pump water to the sump.
- Sump is in line with a secondary holding tank for sump overflow at Low Tide.
- 195.4 gal returning to sump in a Low Tide scenario
- 30 gal in sump pump
- 107.39 gal in sump (freeboard volume)
- 58.01 gal necessarily pumped to secondary holding tank

- Flow rate for each tank is 2-6 GPH (See Tidal Manipulation for specific flow rates).
- Chiller is plumbed inline with the filtration skid which includes mechanical/biological filtration as well as UV sterilization (chemical filtration).
- One main pump recirculates the water flow throughout the experimental tanks and the main holding reservoir.
- Each tank has an immersion heater that allows tank temperatures to be set 15 degF (8.3 degC) above the main holding tank reservoir.
- **Note: The tank needs to be static in order to heat up to a desired temp. Once the temperature has been reached then it can be set to flow through mode.**
- A small sumbersible powerhead in each tank provides water circulation throughout the tank.
- Each tank has (2) supply lines, each with (1) flow sensor, and (1) gate valve in line with (1) supply line for tidal effect. Each tank also has (2) drain lines with (1) flow sensor. Incoming and outgoing flow rates have to be manually adjusted for the tidal effect.
- outgoing tide: incoming flow rate to be lower than outgoing flow rate.
- incoming tide: incoming flow rate to be greater than outgoing flow rate.
- Note: The tank will not be completely empty during low tide events to prevent the recirculating powerhead from running dry.
- Each tank has (1) CO2 supply line with an airstone connected to (1) solenoid valve to lower pH in tanks.
- Air compressor connected to a CO2 scrubber will bubble air into the sump to bring pH to ambient or near-ambient conditions in the holding reservoir.
- Each tank has individual LED lighting.
- Tanks controlled via Neptune Systems Apex Controllers. Each Apex controls (4) tanks.
- Controllable parameters are pH, temperature, tidal effect, and lighting.

Apex Connection Series

- Each EnergyBar connects to the Base Unit with an AquaBus cable via the AquaBus Ports for power. (2) EB832 units connect to (1) Base Unit.
- Each CO2 Solenoid valve connects to the EnergyBar via the DC24 Accessory Port on the side of the EB832. (2) Solenoid valves connect in (1) EB832.
- (1) PM1 connects to (1) EnergyBar with an AquaBus cable via the AquaBus Ports, and all PM1 modules connect in series with each other for power.
- VDM connects to the last PM1 in series with an AquaBus cable via the AquaBus Ports for power.

- Temperature probes connect to the PM1 Temp Port or the Base Unit Temp Port. (1) Temperature probe in each PM1, and (1) Temperature probe in the Base Unit.

- pH probes connect to the PM1 pH/ORP Port or the Base Unit pH/ORP Port. Push the BNC female connector of the probe on to the male connector and turn 1/4 turn clockwise to lock the connector in place. (1) pH probe in each PM1, and (1) pH probe in the Base Unit.

- Halo light connects to the VDM or Base Unit via the V1/V2 or V3/V4 Port. (2) Light connections in the VDM and (2) Light connections in the Base Unit.

- (1) FMM connects to (1) EnergyBar (whichever EB832 is not powering the PM1 modules) with an AquaBus cable via the AquaBus Ports, and all FMM connect in series with each other for power.

- (3) Flow sensors connect to each FMM via (3) of the numbered ports.

EB832 Outlet Connections

Note: Each horizontal row on an EB832 corresponds to one tank, yielding 4 outlets per aquarium. In order:

1. 200W Heater
2. Hydor Powerhead
3. Water supply line “S” Solenoid
4. Halo Light

Chapter 4

Inventory

Contents
- **Experimental Mesocosm** - **Filtration** - **Spare Items**

Experimental Mesocosm

Item	Quantity
Experimental Aquarium	20
Aquarium Lid	20
200W Heater	20
Suction Heater Slip	40
Halo Light	20
Halo Light Power Cords	20
Hydor Powerhead	20
Temperature Probe	20
Suction Temperature Probe Slip	20
pH Probe	20
Suction pH Probe Slip	20
pH Calibration Pack $4, 7, 10$	10
Solenoid Valve	20
Solenoid Power Supply	20
Flow Sensor	60
Gate Valve	20
Inflow Seawater Tubing	40
Inflow CO2 Tubing	20
Airstone	20
Inflow Tubing Stand	40
VDM	5
FMM	20
PM1	16
Apex Base Unit	5
Apex EB832	10
Tunze CO2 Regulator Valve	1
180gal Sump	1
Chiller	1
Heat Pump	1

Filtration

Item	Quantity
PhosBan Chemical Filter with Media	1
Cascade Water Pump	1
UV Sterilizer	1
UV Light	1
CO2 Scrubber	1
Airflow Tubing	4
Airstone	4
Carbon Filter Cell	3
Matala Filter, High Density (Blue)	4
Matala Filter, Low Density (Black)	4

Spare Items

Item	Quantity
Solenoid Valve	4
Airstone	29
Halo Light Cable	16

Chapter 5

Start-up Guide

Contents
- Basic Operation
- Filtration
- System

Basic Operation

1. Operating water level in the filtration sump should be 7" in the filter cell compartment.
2. Overflow water from the tanks will feed down to the outside sump pump, then into to the filtration skid inside the Citrus Hall Field Room. The water will then be pumped through the UV sterilizer and chiller, then back to the tanks.
3. Inflow from the filtration sump to the mesocosm tanks
    1. Water in the sump is pulled through the three carbon filters by a pump and pushed up into the UV filter, where is is then directed through a chiller chamber.
    2. Water from the chiller can be directed either back into the sump (t valve 1 is parallel with the pvc, opening flow to the sump, and t valve 2 is perpendicular to the pvc, closing flow to the tanks) or to the mesocosm tanks (t valve 1 is angled to allow partial flow to the sump and tanks, and t valve 2 is parallel with the pvc, opening flow to the tanks). T valve 1 is used to regulate the line pressure going back to the mesocosm tanks. The more closed, the higher the pressure in the line, and the more open, the lower the pressure. The chiller has a safety flow switch that requires a minimum flow rate for the chiller to operate, so the bypass valve can be used to regulate the chiller flow as well as the container flow.
4. Outflow from the mesocosm tanks to the filtration sump
    1. Water from the tanks drains to an outdoor sump pump, which will automatically pump water out when a certain water level is reached. This water can be directed either back into the sump (t valve 3 is opened parallel with the pvc, allowing flow to the three dump pipes into the filtration skid), or if you intend to drain water in the event of a water change or the end of an experiment, water can be directed to a drain port (t valve 3 is closed and t valve 4 is opened parallel with the pvc).
5. Overflow from sump to secondary containment
    1. When mesocosm water level falls from a high tide to low tide sequence, more water will drain to the sump than what the sump can individually hold. Excess water can be redirected from the sump (S1) to the secondary containment (S2) by opening t valve 5 (allows simultaneous flow of filtered, chilled water to both S2 and the mesocosm tanks), and t valve 6 (allows continuous flow exchange between S1 and S2).

6. There are two valves located along the chiller flow line
    1. One controls the flow directly back to the tanks
    2. The other valve is the bypass valve which diverts the flow back to the sump This is used to regulate the line pressure going back to the container. The more closed, the higher the pressure in the line, and the more open, the lower the pressure. The chiller has a safety flow switch that requires a minimum flow rate for the chiller to operate, so the bypass valve can be used to regulate the chiller flow as well as the container flow.
7. Before filling the tanks make sure the drain valve located under the tank is closed.
8. Fill each rack one at a time and make sure rack and filtration skid flows are balanced before moving on to the next rack.
9. Make sure the complete system reaches equilibrium in standard recirculation mode before setting up the tidal cycle.

Chapter 6

Tidal Manipulation

Controling the tidal cycle of each experimental tank with the Apex. This is achieved by manipulating the incoming and outgoing flow rates of each individual tank with the needle valves described in the System Details, and setting the ON/OFF time cycle of the supply line with the solenoid. The basic procedure is outlined below.

1. Set the flow rate of the supply line N[#]FLW (without the solenoid), for example 10.5 Liters/Hr, by slowly turning the black knob counterclockwise to increase flow or clockwise to decrease flow.
    1. You can view rates on the Fusion dashboard.
    2. Note that the Apex controller has some lag time in registering the flow rate after the valve has been adjusted, and the delay can be up to 30 seconds or more, so make small adjustments and monitor the change on Fusion.
    3. Once the rate is set you should check periodically to make sure the rate has not changed both on Fusion and by using a graduated cylinder and a timer.
2. Adjust the outgoing flow rate of the drain line D[#]FLW higher than the N[#]FLW, for example 15 Liters/Hr.
    1. With the above condition, the outgoing flow rate is higher than the incoming, so this will create a low tide effect over a 5-5.25 hr period.
3. To create a high tide effect, change the setting of SOL-TNK-# (outlets 3 and 7 on each EB832) to ON on the Fusion dashboard, then manually turn on and adjust the flow rate of the supply line S[#]FLW , for example 10 Liters/Hr.
4. Once the S[#]FLW is set, change the setting of SOL-TNK-# to AUTO on the Fusion dashboard.
    1. With the above condition, the total incoming flow rate (N+S) is higher thatn the outgoing (D), so this will create a high tide effect over a 5-5.25 hr period.
    2. For a constant ON/OFF cycle over a 12.5 hour period, the Advanced program should look like the program below:

Fallback ON
Osc 000:00/375:00/375:00 then ON

1. In the event the EnergyBar loses connection with the Apex Base, “Fallback ON” will keep the solenoid open, allowing water to continuously flow from S[#]FLW.
2. The oscillate (Osc) command as written will open flow from S[#]FLW for 6.25 hours, initiating the High Tide scenario, then close for 6.25 hours, initiating the Low Tide scenario. This will provide the effect of two high and two low tides of a semidiurnal tidal cycle over a 25 hour period.

1. Using the flow rates stated above, each tidal shift will last 5.25 hours and maintain the tide height for 1 hour.

For more advanced programming features, see the Comprehensive Manual. Start on Page 65 for Seasonal Features and Moon cycles.

Chapter 7

Controlling pH

The pH is controlled with the addition of CO_2 gas to the system. The gas is delivered to the tank by air stone and is controlled through the Apex Controls with a solenoid valve connected to the EB832.

1. Once the CO_2 regulator is connected to a tank, open the main tank valve.
2. Use the pressure adjusting screw to adjust the pressure (in bar) on the pressure gauge. Turning **clockwise to open**, thus increasing pressure, while turning **counterclockwise to close**, thus reducing pressure.
3. The pressure should be set to 0.5 up to 1 bar on the gauge (~7.5psi)
4. Open the fine adjustment valve to allow gas to the tank solenoid. If the pressure on the gauge is too high this may prevent the CO_2 solenoid from completely closing, which will inject excess CO_2 into the system.
5. Programming the solenoid: pH-TNK-#

Control type: pH Control
Probe name: pH
Fallback: OFF
High Value: 8.2
Low Value: 7.9
On when: High

Refer to Comprehensive Manual for set point programming.

Chapter 8

Apex Programming Guide

Recommendations for programming the Apex aquarium controllers designated for the Silbiger Lab Mesocosm, located in the loading bay between Citrus Hall and Eucalyptus Hall at California State University, Northridge. These recommendations are for maintaining tanks at ambient conditions. Changes should be made according to your study aims.

The following are using the numbered system of Apex_39106, controlling tanks 1-4. All methods are transferrable across all 5 Apex controllers to yield the same outcome in all 20 tanks.

Contents
- **Probes**
- **Modules, Outlets, and Ports**
- **Outlet Setup in ApexFusion**
- **Profiles**

Probes

- TMP-1 (Base)
- PH-1 (Base)
- TMP-2 (PM1_2)
- PH-2 (PM1_2)
- TMP-3 (PM1_3)
- PH-3 (PM1_3)
- TMP-4 (PM1_4)
- PH-4 (PM1_4)

Modules, Outlets, and Ports

- Base Unit
- WHITE-TNK-1
- BLUE-TNK-1
- WHITE-TNK-2
- BLUE-TNK-2
- SndAlm_I6
- SndWrn_I7
- EmailAlm_I5
- Email2Alm_I9
- EB832_1
- HEATER-1
- PWRHD-1

- SOL-TNK-1
- LIGHT-TNK-1
- PH-TNK-1
- HEATER-3
- PWRHD-3
- SOL-TNK-3
- LIGHT-TNK-3
- PH-TNK-3
- EB832_2
- HEATER-2
- PWRHD-2
- SOL-TNK-2
- LIGHT-TNK-2
- PH-TNK-2
- HEATER-4
- PWRHD-4
- SOL-TNK-4
- LIGHT-TNK-4
- PH-TNK-4
- VDM
- WHITE-TNK-3
- BLUE-TNK-3
- WHITE-TNK-4
- BLUE-TNK-4
- BluLED_11_5
- WhtLED_11_6
- FMM_1
- S1-FLW
- N1-FLW
- D1-FLW
- FMM_2
- S2-FLW
- N2-FLW
- D2-FLW
- FMM_3
- S3-FLW
- N3-FLW
- D3-FLW
- FMM_4
- S4-FLW
- N4-FLW
- D4-FLW

Outlet Setup in ApexFusion
All configurations are for Control Type: Advanced

- HEATER-#
- Fallback OFF
  Set OFF
  If Tmp-# < 15.0 Then ON

- PWRHD-#
- Fallback ON
  Set ON

- Alternative program is to set Control Type: Always

- SOL-TNK-#
- Fallback ON
  OSC 000:00/375:00/375:00 Then ON

- LIGHT-TNK-#
- Fallback OFF
  Set OFF
  If Sun 0/0 Then RampUp
  If Moon 0/0 Then ON

- WHITE-TNK-#
- Fallback OFF
  Set OFF
  If Sun 0/0 Then ON

- BLUE-TNK-#
- Fallback OFF
  Set OFF
  If Moon 0/0 Then RampUp

- WhtLED_#
- Fallback OFF
  Set OFF
  If Sun 0/0 Then ON
  If Tmp-# > 35.0 Then OFF
  Min Time 030:00 Then OFF
- BluLED_#
- Fallback OFF
  Set OFF
  If Moon 0/0 Then ON
  If Tmp-# > 35.0 Then OFF
  Min Time 030:00 Then OFF

Profiles

- RampUp:
- Type: Ramp
- Ramp Time: 30 min
- Start Intensity: 0
- End Intensity: 100

Chapter 9

Apex Fusion

To access the Silbiger Lab Fusion account, go to ApexFusion.com, click "Get Control" and enter the login information:
Username: SilbigerLab
Password: silbigerlab

Contents
- **Dashboard Display**
- **Module Setup**
- **Outlet Setup**
- **Downloading Data Logs - Update System**

Dashboard Display

- Left column displays the current system time, Reminders, and Temperature and pH trending line graphs for each tank.
- Middle and right columns display the Watt, Amp, and Volt readings for each EB832, the state of each outlet (OFF, AUTO, or ON), and the flowmeter readouts for the N-valve (continuous inflow), S-valve (controllable inflow) and D-valve (outflow) for each tank.
- You can manually control the state of the outlet by moving the slide bar to either OFF or ON. To let the program settings control the outlet state, move the slide bar to AUTO.
- Adjusting the Solenoid status bar to OFF will stop flow from the S-valve, while adjusting the status to ON will open flow from the S-valve. Adjusting the status to AUTO will allow your program to control when the Solenoid opens and closes.
- To modify the dashboard (add, remove, or reorganize items), click the padlock icon in the upper right-hand corner then click and drag a tile to move it or click the "x" to store it in the upper tile bank.

Module Setup

1. Expand the Options menu and select the Modules icon to view all modules.
2. Click any module to view a summary of its connection and software status, rename the module, or perform an action with that module (Configure, Update Software, or Delete).

Outlet Setup

1. Click the Outlets icon in the upper left-hand options bar.
2. Outlets are arranged by the name you give them, the module they're associated with, the type of output, and whether or not you have chosen to log activity.

3. Select an outlet to modify its name, display symbol, and program settings.
    1. To use a program template, use the "Control Type" dropdown menu to select which item you intend to use in this outlet location, then fill in the required information to control the outlet state.
    2. To write your own program, select Advanced from the dropdown menu, and write your progrm in the source code box that appears.
4. Once you've completed your settings and program, click the orange cloud icon in the upper right to send your new settings to the Apex.

Downloading Data Logs

When connected to the same network as the Apex units, you can download data logs for the systems following the directions below.
Note To connect to the same network, you must plug your device into one of the live ethernet cables in the Mesocosm.

Format for your internet browser URL:
http://:/cgi-bin/outlog.xml?sdate=yymmddhhmm&days=n
http://:/cgi-bin/datalog.xml?sdate=yymmddhhmm&days=n
* Accessible logs: * Outlog – every time the Apex changes the state of an outlet a record is written to this log. If no outlet ever changed state you would have zero records in this log. A new log is started daily at midnight. Log is named "yymmdd.odat". * Datalog – records probe value snapshots (Temp, pH, ORP, etc.) based on the logging interval you define (default = 20 minutes). You can change the interval via the Display module under Data Log – Log Interval. A new log is started daily at midnight. Log is named "yymmdd.pdat".

Examples of what to enter into your internet browser:
http://172.24.113.25/cgi-bin/outlog.xml?sdate=191005
http://172.24.113.25/cgi-bin/outlog.xml?sdate=191005&days=7

- The value after date= is the start date for when you want logged information, and days=n yields data n days after that start date.
- Hours and Minutes are optional in the date parameter.

1. Following the above format, enter the unique IP address for the Apex containing the logs you want to access.
    1. Apex_39106: 172.24.113.25 Apex_40216: 172.24.113.22 Apex_39952: 172.24.113.23 Apex_37810: 172.24.113.21 Apex_41239: 172.24.113.24
2. Import Log Data
    1. Open a new Excel file and go to the Data tab
    2. Select From Web in the Get External Data box
    3. A New Web Query dialog box will open. Type or copy the url from your browser into the data source Address field. Click Import.
    4. Your XML data should be imported into your empty spreadsheet and automatic filters created for each column making it easy to select and analyze data.

Update System

1. From the Apex List menu
    1. If the orange icon next to the apex name shows an upward facing arrow in a circle, click that icon and select "Update Available" from the dropdown menu.

    2. The popup window will display the current AOS version and the most recent AOS version available for the system. If the popup says “it’s recommended that you update”, then make sure the Apex is connected via ethernet cable and click “Update”.

2. From the Dashboard Display

    1. Click the down arrow next to the apex name in the upper left corner and select “Network” from the dropdown menu.
    2. Under “Apex Operating System” you can view the installed AOS and Available AOS. If the installed version is out of date, there will be an orange bar next to “AOS Update” reccommending you “Update AOS”. Click the bar, then make sure your Apex is connected via ethernet cable and click “Update”.

3. Once the system has completed the update, go to your Modules page. If any modules need to be updated (under “Status” there will be an error icon rather than a check mark), click that module and change the Configuration Action to “Update Software” then click the orange cloud icon.

Chapter 10

Breaker Box Connections

Following switches from top-down, then left-right:

1,3: Main Disconnect
5,7: Air Conditioner
9,11: Condenser (Chiller, Filtration)
2: General Power (Lights and Outlet Box #1)
4: Outlet Box #2 (Tanks 17-20)
6: Outlet Box #3 (Tanks 13-16)
8: Outlet Box #4 (Tanks 9-12)
10: Outlet Box #5 (Tanks 5-8)
12: Outlet Box #6 (Tanks 1-4, outdoor sump pump)

Powering the container:

1. Turn on (flip left to right) the Main Disconnect switches. Once powered, the remaining switches will supply power to their individual breakers.
2. Turn on (flip right to left) the General Power switch. Once powered, the light switch to the right of the entrance will turn on/off the overhead light, the O2 sensor above the light switch will be activated, and all outlets in Outlet Box #1 will be active.
3. Turn on (flip left to right) the Air Conditioner switches. Once powered, the A/C unit can be controlled via remote control or the front display panel on the unit.
4. Switches 4, 6, 8, 10, and 12 all correspond to outlet boxes lining the upper perimeter of the container. Each box is used to power up to two (2) Apex units and enough modules and other devices for up to four (4) tanks. Each outlet covering has a number corresponding to the labeling for these switches. To turn any or all on, flip the switch(es) right to left.
5. Leave the Condenser switches (9 and 11) in the "off" position unless the chiller and filtration system become connected

Chapter 11

Troubleshooting Guide

Contents
- **Tripped Breaker**
- **Flowmeter Misreadings**
- ** **
- ** **

Tripped Breaker * Breaker tripped in the field room (pump, UV filter, CO2 scrubber all off) 1. Call PPM (ext. 2222) and let them know a breaker tripped at Citrus Hall in the room next to the Mechanics Room on the outside and South side of Citrus. 1. When PPM arrives, let them know the breaker box is on the 3rd floor of Citrus in Room 3303 and the switch is for EDP C-4 1. Check for other items plugged into EDP C-4 outlets and alert PPM of anything that shouldn't be plugged into those outlets (e.g. CSUN golf carts)

Flowmeter Misreadings * Flowmeter on ApexFusion is reading 0 or some incorrect value * Sometimes the flowmeters (FM) inline with water flow will either have a bubble or some debris affecting the spin of the turbine within the FM. 1. Make sure to check the flowmeter connections back at the FMM module for a connection issue. Unplug and plug back in the cable for the FM in question. 1. Try clearing bubbles. If gently tapping the FM doesn't resolve the issue, you may have to remove the FM to clear it out. *Removing the FM for cleaning 1. Unscrew the FM at both of its compression fittings until the fittings are loose on the tubing, then pull gently at the tubings to remove them from the FMM (if the compression fitting is all the way unscrewed, but the tube isn't coming out of the FMM, pull a little harder beacuse sometimes the tubing just gets stuck in the FM). 1. Visually expect the inside of the FM, and if needed, use a small long object to probe and spin the internal turbine to dislodge any debris.

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