Aqua Monitor 4 – Operating Manual

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2.0 Introduction

Aqua Monitor model WMS-4 is a water and phytoplankton sampler designed and manufactured by EnviroTech Instruments LLC. Applications of Aqua Monitor include sample acquisition for phytoplankton biomass and species composition analysis, plant nutrient concentration, chlorophyll concentration, micro-nutrient analysis, suspended load measurements and salinity calibration.

Aqua Monitor has four major components. These are a forty-eight port rotary valve, a motor driven syringe, a control valve which switches between a sample inlet port and a sample bag port, and an electronic controller. In addition each complete sampling system will require up to forty-eight sample bags, tubing, an external power source and a mooring frame or brackets.

Because of Aqua Monitor's suitability for use in a diverse range of applications, such as within remote vehicles, taught-line moorings and surface buoys, many accessories are offered as optional extras. These include mooring frames, fixings & brackets, battery-packs, sample bags, tubing and chemical preservatives.

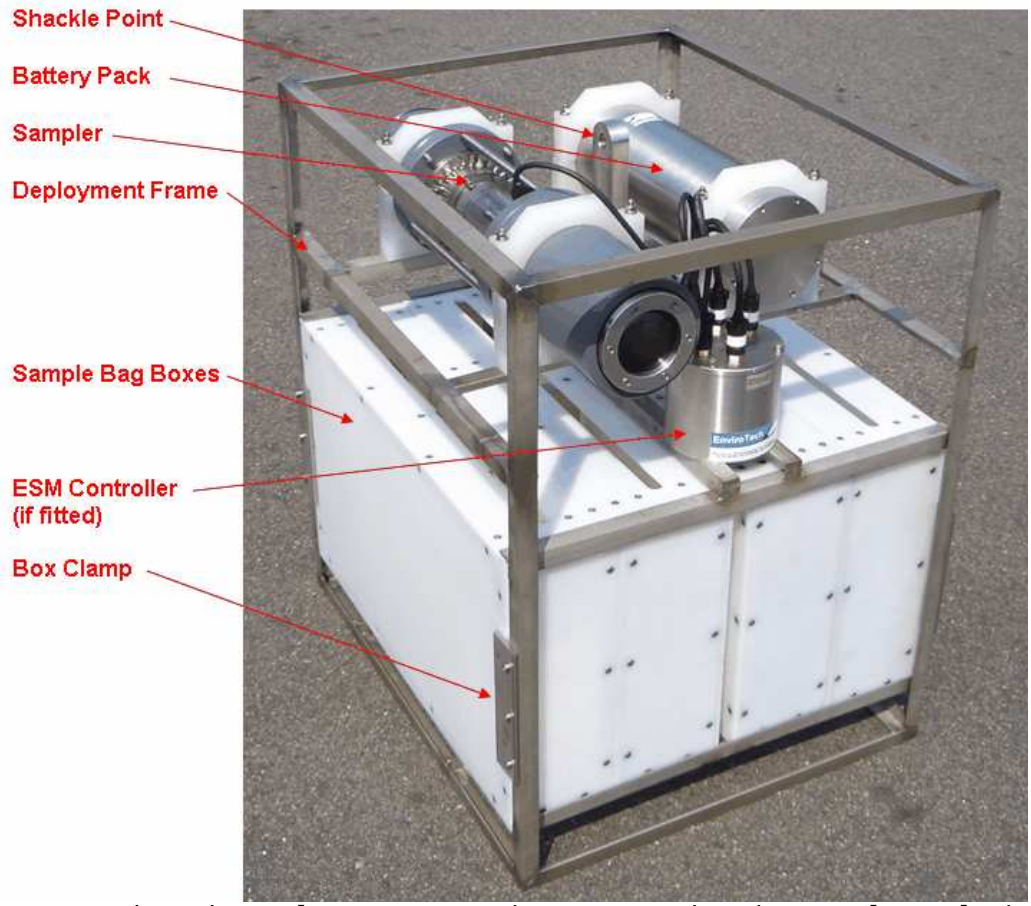
The rotary valve and syringe are both driven by stepper motors controlled by an electronic controller. Samples are stored in the reagent housing in plastic "IV" bags. Further details are given in the following sections.

A sample is taken by withdrawing the syringe plunger when the rotary valve is aligned or switched to the inlet port (depending on the version). A sample is collected by moving the valve from port to port, possibly adding reagents to the sample (by retracting the syringe plunger further at the preservative port). The sample is then injected into the sample bag connected to the appropriate valve port.

Aqua Monitor can collect discrete or integrated samples at a user programmable interval. Housekeeping data (battery voltage, date, time, port number) from each sample is stored in memory for data extraction after recovery. Between samples Aqua Monitor is dormant and in a low power state. Aqua Monitor can also be used on-line or in telemetry applications, where triggered sampling is of use.

Depending on the version the sampler utilizes a partially or totally pressure balanced system to avoids depth limitations. Pressure balancing is achieved by the hydraulic circuitry being external to the instrument and at ambient pressure. Only the motors, electronics and battery are contained in sealed pressure housings.

Aqua Monitor is programmed and operated via a serial communication link to a PC running any terminal emulator software.



Aqua Monitor in Deployment Frame (4000 m version / 1000 ml samples)

3.0 Getting Started

3.1 General Advice

To get the best results out of your Aqua Monitor it is important that you allocate sufficient time to familiarize yourself with all the features described in the documentation package and take the time to practice with the instrument.

An on-site training course is highly recommended and these can be arranged at a convenient time and place. Please contact your supplier for further details.

The beginner should start with manual operation and individual samples. Then familiarize yourself with programming the instrument for deployment.

Once you feel comfortable with the basic operation of Aqua Monitor move on to prepare for mock and then full deployments.

Servicing and maintenance are very important aspects of operating Aqua Monitor and the servicing routines are described further in the Maintenance section

New users of Aqua Monitor are advised to perform several short or "accelerated" test deployments prior to using the instrument in the field. It is not necessary to immerse Aqua Monitor, it will perform sampling operations in air on the laboratory bench.

Your preparation should include practicing the deployment in the laboratory and at a local site if possible. If you are going to be responsible for the deployment it is strongly recommended that you practice so that you are able to use the instrumentation and software without assistance from your colleagues. Always assemble all the equipment in the deployment frame that you are going to use prior to your field deployment.

- Read the operating manual
- Don't cut familiarisation time short
- Carry out regular maintenance
- Don't over tighten screws and nuts etc.
- Fit communications dummy plug prior to deployment
- Double check everything and ask if unsure
- Don't leave tube clips on for deployment

3.2 Unpacking

Carefully unpack Aqua Monitor and the accessories supplied. Inspect each item for shipping damage and ensure that the inventory is correct by identifying each item on the packing list. If any items are damaged or missing please contact your supplier immediately. Upon receipt of the instrument it is advisable to check components and fasteners for security.

Aqua Monitor should be placed vertically on a flat surface. Do not attempt to open or operate your Aqua Monitor until you have read and understood the contents of this manual.

3.3 Equipment

The following equipment is required to power-up and communicate with your Aqua Monitor:

- A 12 volt DC ***regulated*** power supply capable of supplying 12 volts at 4 Amps
- The communications and power deck leads
- A personal computer (PC) with a spare RS232 port
- VT100 compliant Terminal Emulator software

Please note that the single most frequent problem encountered with customers new to Aqua Monitor is the use of an inadequate or inappropriate power supply. We can supply or recommend a suitable model of power supply. Please do not hesitate to ask.

3.4 Connecting Up

STEP 1

- Boot-up your PC in the normal way.
- Take the communications cable and connect the D-type connector to your spare RS232 COM port (COM1 on your PC is the default = easiest).
- Carefully plug the other end into the user serial connector of the Aqua Monitor. This is on the linear pressure case on the 100 rated version. On the 4000 m rated version the serial connector is on the separate electronic controller module.

Note: For the 100 version communications & power are connected via one deck lead. For the 4000 m version there are two separate cables.

4000 m VERSION ONLY

Connect the cables between the electronics housing and the sampler. Each bulkhead connector and cable is numbered.

Electronics Unit	Sampler
1. Battery / power cable	
2. Communications	
3. Rotary Motor	>> Connector on valve housing of sampler
4. Shaft Encoder	>> Connector on valve housing of sampler
5. Linear Motor	>> Connector on syringe housing of sampler

STEP 2

- If the power supply is new to you it is highly recommended that you check the voltage output with a digital voltmeter (DVM) or multi-meter before connecting up. The Aqua Monitor will be damaged by excessive voltage, so ensure the supply voltage is a nominal 12 volts and certainly in the range of 9 – 15 volts.
- Ensure the power supply is switched-off and connect positive/red terminal to the red jack plug on the cable and negative/black to the black jack plug.
- Carefully plug the other end into the communications and power connector of the Aqua Monitor.
- Don't switch-on yet!

STEP 3

- Launch a terminal emulator
- Set up the communications protocol for 19,200 baud, no parity, 8 bits, 1 stop-bit (19200 N81)

Turn on the power or plug in the battery pack.

The unit will "sign-on" with the following message:

WMS-4 V1.10x

If the unit has previously been put into auto-sampling mode you must press the "ESCAPE" key within 20 seconds (default) of applying power to avoid running an auto-sampling routine.

If Aqua Monitor fails to "sign-on" within a few seconds, power-down and check the following:

1. The instrument is powered-up (check leads and connections). If using a battery check the voltage on the battery or lead terminals.
2. The deck-lead is properly connected and to the right COM port
3. You selected the correct COM port when you attempted to connect to the instrument
4. The Baud rate is correct (19200)
5. The COM port you have selected is working properly (check in the Windows / Settings / Control Panel / System / Hardware dialog)

If you are having difficulty please contact the factory for your distributor for technical support (see section the Technical Support section).

Sign-on sequences

Command mode

WMS-4 V1.10x
@CMD
(few seconds delay)
>

Auto-sampling mode (M command previously used)

WMS-4 V1.10x
(press ESCAPE key)
@OK!
@CMD
(few seconds delay)
>

Power-cut / stepper interrupted

WMS-4 V1.10x
@CMD
@MOT
(few seconds delay)
>

The @MOT message means that a power-cut occurred during operation when the stepper motors were last enabled. You should re-align the valve before sampling. See the following sections.

4.0 Operation

4.1 Main Components

To use Aqua Monitor effectively you must familiarise yourself with the basic anatomy of the system and some technical issues. If you are not familiar with electronic instrumentation you may find some concepts challenging at first. However, you will soon become comfortable with these aspects.

The rotary valve and syringe are both driven by stepper motors and the control valve by a servo motor, all controlled by the electronic controller. A water sample is taken by withdrawing the syringe plunger when the control valve is at the sample inlet port. The sample enters the syringe chamber. The sample is then dispatched to the sample bag by inserting the syringe plunger with the control valve at the sample bag port. Once complete the rotary valve is aligned and turned clockwise to the next sample port and the control valve returns to the sample inlet port.

The user communicates with Aqua Monitor via an RS232 link to any desktop or notebook PC with a spare COM port and Aqua Monitor is supplied with a communications and power deck-lead for use in the laboratory.

48-port valve

The valve incorporates 48 sample ports. Ports may be user allocated to samples, preservative, or as in/outlets.

The valve consists of two banks of 24 ports in the valve body, one above the other. The two rows of ports are staggered, with the lower row between two on the upper row and so on. The internal rotor has two horizontal ports which align with the two banks on the valve body. Both connect to a central port within the rotor, which connects vertically to the syringe chamber to complete an "F" shape. Nitrile (Buna N) o-rings at the bottom of the "F" seal between the rotor and the syringe chamber.

The 48 ports in the valve body each have a nitrile o-ring seal, as do the two matching ports on the rotor. The rotor o-rings align and seal with the valve body port seal on one of the two banks of ports. The other rotor o-ring seals against the bore of the valve body. The o-rings prevent contact between the surface of the rotor and the bore of the valve body.

Two nitrile o-rings prevent contact between the ends of the rotor and the valve body. The bore size within the valve and rotor is 2 mm diameter at its narrowest.

The valve rotor is driven by a tongued coupling, which in-turn is driven by the valve motor and gearbox assembly.

3-port switching valve (100 m version only)

The switching valve (control valve) is similar in principle to the 48 port valve. It connects either the external sample or the sampling bag ports to the syringe. When the Aqua Monitor is in auto sampling mode the valve automatically selects the appropriate port. The adjustment of the torque of the port adapters follows the same procedure as the 48 port valve. A detailed diagram of the switching valve is provided in the servicing section.

4.2 Electronic Configuration

The user communicates with Aqua Monitor via an RS232 link. This is a common serial interface and communication protocol found on most desktop PCs and many laptop computers. It may be necessary to install an RS232 "card" in your computer to provide a suitable COM port. If you have any queries please do not hesitate to ask.

Aqua Monitor contains the main electronic controller unit and the ELF-STEPPER motor driver. The motor driver is an individual devices that has its own microprocessor built-in.

4.3 Hydraulic Configuration

Aqua Monitor hydraulic system has two or three major components and comprises a 48-port valve and a syringe for all versions. For the 100 m rated version a 3-port switching valve is also incorporated as shown in the block diagrams below.

Each valve port can be uniquely selected by the valve motor controller. If the valve is positioned at port "n" inserting the plunger will inject the fluid into either into the sample bag or back out of the inlet depending on the 3-port valve position. The valve is usually moved "to" a port. That is, you will either manually or programmatically move the valve to port 1, 2, 3, etc.

The valve has an encoder index point a short distance counter-clockwise of port 1. This is an arbitrary reference point that provides the valve drive system with an absolute reference. The distance to port 1 is then calibrated and this is known as the valve offset. Indexing the valve only moves it to the valve reference point. It must then be moved to a port before fluid can be draw into or expelled from the syringe.

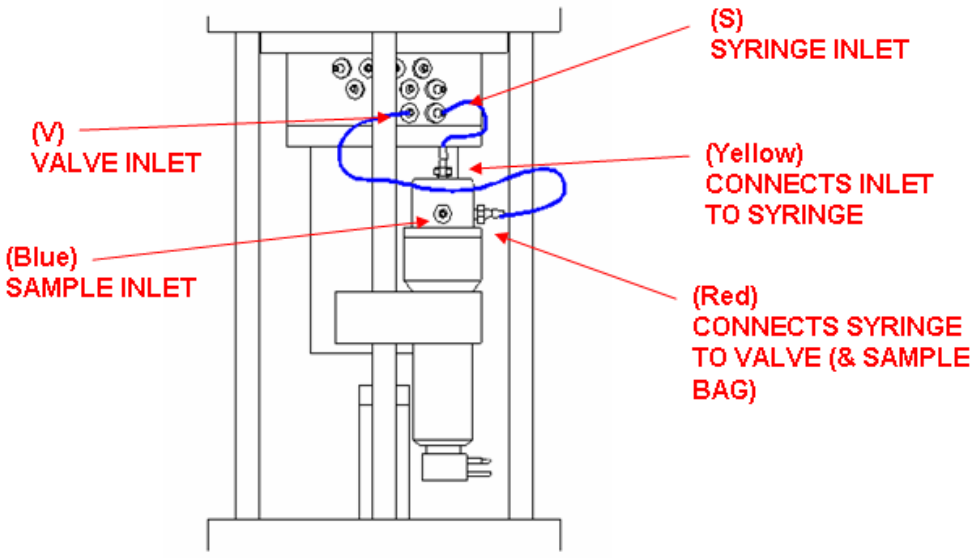
The syringe can be inserted or retracted a number of "steps". These are individual stepper motor steps and the full travel is approximately 21500 steps. This equates to approximately 200 ml volume in the syringe. More accurately:

5650 syringe steps = 50 ml volume

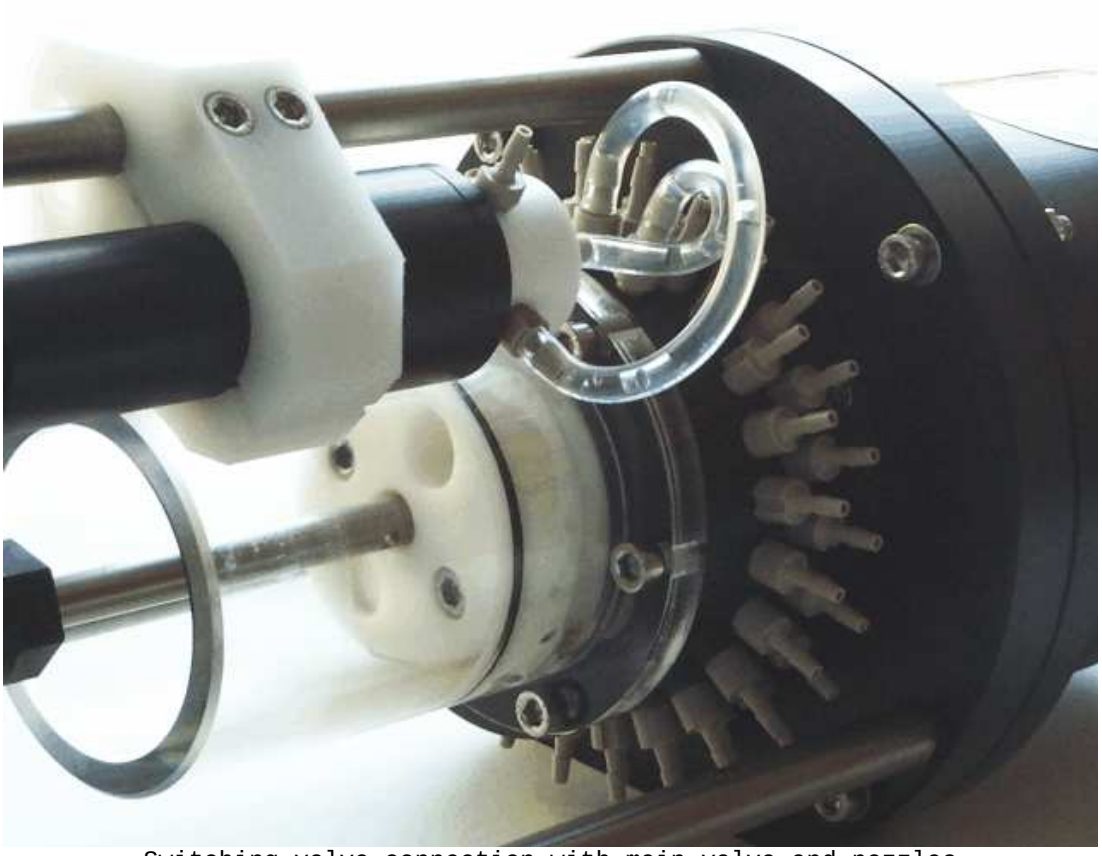
Switching-valve (100 m versions)

A 3-port switching valve is incorporated for the 100 m version of Aqua Monitor. This switching valve isolates the syringe from the valve. The purpose is to allow the syringe to be flushed or a sample captured with the main valve positioned at any port. A typical sampling sequence is as follows:

The tubing connections for the main 48-port valve and the 3-port switching valve are shown diagrammatically below.



Switching valve connection diagram

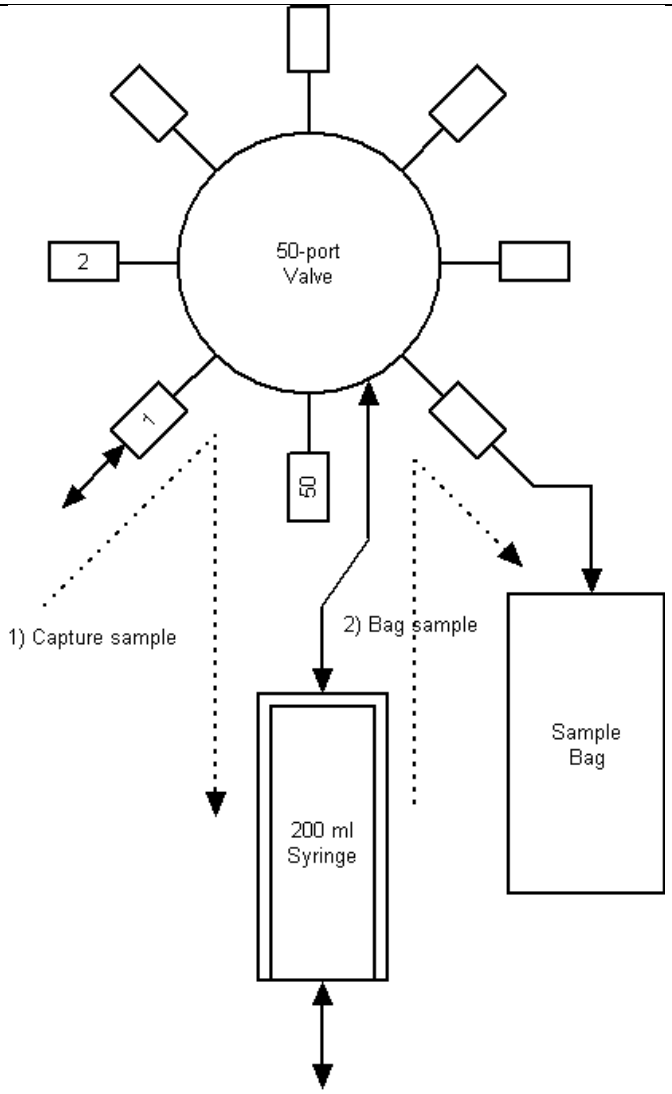


Switching valve connection with main valve and nozzles

4000 m Aqua Monitor Versions

The 4000 m rated version of Aqua Monitor is not fitted with the 3-port switching valve. The Red and Yellow ports on the 48-port valve are "shorted" with a length of tubing. In this case port 1 is designated the inlet. The hydraulic configuration is shown below. A typical sampling sequence is as follows:

1) Move the 48-port valve to inlet port and retract the syringe plunger
2) Move the 48-port valve to the sample bag port and insert the syringe plunger
3) Repeat 1 - 2 if required sample volume greater than 200 ml
4) Move main valve to the next port (to close the sample bag)



Hydraulic block diagram

4.4 Sampling Sequence

It is important to understand that Aqua Monitor operates by controlling the motor drivers. These are shown in the table below:

Device	**Controls**
Valve motor	Rotate (clockwise & counter-clockwise), align valve
Syringe Motor	Insert and retract plunger
Switching valve	Open and close

To take a sample Aqua Monitor would follow the command sequence below:

1. Move to the sample port
2. Open the switching-valve
3. Retract plunger
4. Close the switching-valve
5. Insert plunger

4.5 Command Mode

Aqua Monitor can be operated manually by issuing single commands to control movement of the sampling valve, syringe plunger or switching valve.

All commands are in the format:

<command><argument><CR>

Where:

<command> is a single character

<argument> is a number

<CR> is carriage return or the ENTER key

Examples

To move to port 14 via the shortest distance the command is:

P14<CR>

Insert the plunger 5650 motor steps:

+5650<CR>

See the User Command Set in Section 5 for full details.

4.6 Home Position

Before auto-sampling Aqua Monitor must be put into its home-position. This is plunger fully inserted, sampling valve at port 1 and switching-valve closed.

Syringe

The "+" command is used to insert the plunger. Enter +xxxx<ENTER> until the plunger reaches the end-stop any you here the clutch engage (clicking sound). The plunger can be over-driven by it is recommended to keep this to a minimum to reduce wear.

Sampling Valve

The "G" command is used to align the valve at port 1. The valve rotor is moved clockwise to the index position. Then it moves through the pre-set offset to align at port 1.

Switching-Valve

The switching valve is closed with the "L" command. L1<ENTER> closes the valve.

Once the home position is set the auto-sampling configuration should be entered.

4.7 Auto-sampling

The user must decide on an auto-sampling regime before programming the instrument. The expected deployment duration must be considered and from this the appropriate instrument set-up can be programmed.

The specific issues to consider are:

1. Deployment duration
2. Sampling interval
3. Preservative needed
4. Power budget

The BBP-10 battery pack nominally provides 60 AHrs capacity. Aqua Monitor is a relatively high-current device so not all this energy can be used. However, the power-budget is modest and one cell-pack will provide more than sufficient power for a 48 sample mission.

The sampling interval is from the start of one sample to the start of the next. This is set in minutes in a range of 1 - 65535 (1 minute - 45.5 days)

The auto-sampling configuration is set via the Master Macro (M0). Full details are given in the Command Definition

To set-up for auto-sampling:

1) Create and upload a valid master macro (M0) and at least one sampling macro (M1 – M8)
2) Set the start point (S command) to the desired step in the master macro (M0) - this is typically S0 to start at the "beginning"
3) Check and/or set the real-time clock (H & T commands)
4) Set the wake-up time to the required time in the future (W command)
5) Run the master macro (M0<ENTER>) to launch auto-sampling
6) Wait for the message "@OFF"

At this point the unit may be left powered in a sleep state or unplugged. All settings are non-volatile. When the system is re-powered, if not interrupted within 20 seconds it will either start sampling immediately if the last wake-up time has passed, or power-down and sleep if the wake-up time is in the future.

4.8 Serial Wake-up

When asleep, Aqua Monitor may be woken-up from sleep via the serial port. The command "$$" will wake the system. The sign-on message will be displayed, but the @CMD message will not. In this state the unit is still in deployment mode and immediately starts a count-down of 20 seconds until sleeping again. The ESCAPE key is required to exit deployment mode and return to command mode. This is to prevent the accidental interruption of a deployment by spurious characters.

4.9 Powering Down

Aqua Monitor's ELF-STEPPER uses a low level holding force to combat movement due to tensional wind-up and resulting ping-back. If the unit is abruptly powered-down any wind-up may ping the valve to a new position and the encoder will not be able to measure this. Abruptly cutting power will not harm the instrument, but an align command (G1) must be performed when the unit is re-powered.

The system detects the @MOT condition during auto-sampling and automatically re-aligns if the power has been cut (for example due to an intermittent power cable).

5.0 User Command Set

All commands are in the format:
<command><argument><CR>

Where:
<command> is a single character
<argument> is a number
<CR> is carriage return or the ENTER key

Cmd	Arg	Description	Units	Notes
$	$	Wake from sleep	N/A	See below
+	1 - 66535	Insert Plunger	Motor steps	See below
-	1 - 65535	Retract Plunger	Motor steps	See below
A	0 – 999	Move to valve encoder position	Enc steps	Shortest distance
B	0 – 999	Move to valve encoder position	Encoder steps	Negative direction
C	0 – 999	Move to valve encoder position	Encoder steps	Positive direction
D	1	Download data	N/A	See below
F	password	Reset non-volatile config to default	N/A	
G	1	Align valve to port 1	N/A	Re-zeroes encoder at port 1
H	1	Header information		See below
I	1	Go to encoder index	N/A	This does not align at a port
K	1	Reset stepper driver		
L	0 or 1	Open/close switching valve	N/A	0 = open 1 = closed
M	0 - 8	Run Macro	N/A	See below
N	password	Load new firmware		See below
O	1	Open serial connection to stepper driver	N/A	CTRL-C to close connection. See below
P	1 - 48	Go to port	Port	Shortest distance
Q	1 - 48	Go to port	Port	Negative direction
R	1 - 48	Go to port	Port	Positive direction
S	1 - 256	Set current step in M0 macro		See below
T	1	Set time (RTC)		Format: MMDDYYhhmmss
U	0 – 8	Upload Macro		See below
V	0 - 8	View Macro		See below
W	1	Set wake-up time		Format: MMDDYYhhmmss
X	password	Clear all macros		
Y	password	Clear memory	N/A	
Z	0 or 1	Macro display mode		Volatile setting

password = 5525

Error Messages

@OK! - entry acknowledged
@INV - invalid command
@ARG - incorrect argument (out of range, etc.)
@ALM - start-up alarm set in the past
@MOT - stepper motor powered off when enabled (moving or holding)
@END - end of action (sampling / data download)
@OFF - All circuits powered down in sequence & going to sleep
@RST – Resetting (after serial interrupt)

$$ - Wake From Sleep

The string $$ will wake Aqua Monitor from sleep. The system will reset and then require an ESACPE key within 20 seconds to revert to command mode. If not received the system will go back to sleep in deployment mode (i.e. re-enter the deployment or master macro where it was interrupted).

D – Download Data

Housekeeping data is automatically stored each time a sample is acquired. The data may be downloaded with the D1 command. Regardless of the samples take the data will be downloaded in accordance with the current setting of the S command. In other words if S0 is set no data will be downloaded. However, the data is present. If S1 is set one line of data will be shown. Only the Y command clears data.

Download format

```
Field:   1   2                  3     4
            XX, MM/DD/YY HH:MM:SS, 12.3, 1

            Field 1: sample number
            Field 2: time stamp (start of sample)
            Field 3: supply voltage
            Field 4: Stepper condition (1 = good / 0 = error)
```

H – Header Information

The header command (H1) shows the header. The format is given below.

Header format

```
S3 12.6V
@RTC MM/DD/YY HH:MM:SS
@PWR MM/DD/YY HH:MM:SS
@ALM MM/DD/YY HH:MM:SS

RTC = Real time clock (current time)
PWR = Last power loss time (not sleep time)
ALM = Alarm time set
```

M – Macro Commands

Macros are described in the next section.

N – New Firmware

New firmware may be loaded via the serial port. Updated firmware will be supplied as a “hex” file. (e.g. version.hex).

After invoking the N<password><CR> command the system switches to a resident firmware loader program. At this point the new hex file can be sent using the XON/XOFF protocol at 115,200 baud. Progress is shown as the firmware is uploaded. Once complete the system will reset. Revert to 19,200 baud, power-cycle & establish communications in the normal way. The sign-on message will show the new firmware version.

O – Open serial comms with stepper

The user may communicate with the stepper board (that drives the valve & syringe motors). It is recommended that this is done only after receiving advice from technical support.

S – Set Current Step in M0

The S variable shows the current sample or step number completed in the master macro (M0).

The S variable may also be set by the user to force the system to jump to any J command in the master macro M0 when it is initiated (auto-sampling mode). If S0 is set sampling will start at the beginning of the master macro (M0). Once the first sample is taken S will be incremented. If S10 is set, for example, the next sample will be from port 11. i.e. S10 means 10 samples have been completed.

T / W – Set Time (T) / Set Alarm (W)

Date & time is set in the format 'MMDDYYhhmmss' where time is in a 24 hour format. For date & time entry commands T & W behave in the same way. After T1 or W1 has been entered the date/time capture will open a square bracket [. The time is updated when the last character is entered and the routine will display a closing square bracket.

```
>T1<enter>
[122409235900]
>
```

If the W command is used to set the wake-up time and it is a time that has already passed then the warning @ALM will be displayed.

U – Upload Macros

Macros are described in the next section.

V – View Macros

Macros are described in the next section.

Macro Command Set

Aqua Monitor sampling is controlled by user programmable macros. These are simple ASCII text files. The macros are numbered M0 through M8. The M0 macro is known as the master macro and primarily determines the sample timing, which port is sampled and calls a sub-macro to actually process the sample.

Macros M1 to M8 determine the sampling process and these are know as sub-macros or sampling macros. M1 to M8 can all be different depending on the application. Macro M0 can call any macro M1 to M8.

Master Macro (M0)

The following list contains the only commands valid with the Master Macro (M0):

#JGPM;

Cmd	Arg	Description	Units	Notes
#	N/A	Macro comment		Not uploaded
J	1 – 65535	Interval to next macro	minutes	Timing from start to start of the sample
G	0 or 1	Align before sampling macro	0 = FALSE 1 = TRUE	
P	1 to 48	Sampling port		
M	1 to 8	Run sampling macro	Macro number	
;	0	End of macro		

Master Macro Format
<cmd><arg><CR>
256 samples maximum

4 command lines per sample

Line 1: J<interval><CR>
Line 2: G<align><CR>
Line 3: P<port><CR>
Line 4: M<macro>CR>

Example

```
# Sample / Step 1    Comment
J3          Interval = 3 mins
G1          Align valve
P1          Go to port 1
M1          Run sampling macro 1
# Sample / Step 2
J2          Interval = 2 mins
G0          Do not align valve
P2          Go to port 2
M2          Run sampling macro 2
```

Tips

Time integrated samples may be collected by remaining on the same port. An average of five partial samples may be acquired on each port. For example, a full diurnal cycle could be integrated hourly once a week with background daily spot-sampling for the other samples.

Sampling Macros (M1 to M8)

The following list contains the only commands that are valid within the Sampling Macros (M1 – M8):

#+-ABCGILPQRT;

The commands have the same function as in the User Command Set with the additions below

Cmd	Arg	Description	Units	Notes
#	N/A	Macro comment		Not uploaded
T	1 - 65535	Time delay /pause	seconds	
;	0	End of macro		

Sampling Macro Format

<cmd><arg><CR>

1024 lines maximum

Example

```
# Macro M1        Comment
L0                Open switching valve
T1                Pause 1 second
-20000            Retract plunger 20,000 steps
T1                Pause 1 second
L1                Close switching valve
T2                Pause 2 seconds
+20100            Insert plunger 20,100 steps
;0                End of macro
```

Tips

A pause (T) is recommended between most movements & actions. This allows fluid to finish moving if there is any inertia, slight head or back pressure in the hydraulics.

Pauses may also be used to collect a time-integrated sample (e.g. 5 x 40 ml at 1 minute intervals). However, be aware that the system is in an active state during a pause and excessive pauses will increase the power budget.

Within long complex macros with multiple valve movements a realignment of the valve (G1) is recommended.

6.0 Deployments

6.1 Bench Testing

Functional Test

Aqua Monitor should be bench tested prior to every deployment to ensure it is functioning correctly. The pre-deployment bench test is an assessment of functionality and sampling repeatability.

1. Ensure that the rotary valve is in the correct position before testing the system. The correct starting position is at port 1 and plunger fully inserted. Aqua Monitor is supplied in the start position. If required the valve can be realigned by using the align command under manual control
2. Place the inlet tube in a large beaker of blank sample (DIW or LNS).
3. Pre-weigh enough sample bottles, beakers or bags of sufficient volume for one sample each for the number of samples to be tested. This will typically be between 10 and 48 sample bottles. Mark each bottle with its weight in grams.
4. Place each of the outlet tubes for the ports / samples to be tested into a separate bottle. If doing a limited test set then the samples should be evenly dispersed around the valve.
5. Set the configuration
6. Run the auto-sampling routine
7. Watch Aqua Monitor perform the test. Look for any signs of sample leakage or mis-sampling. Make sure the system starts correctly and the samples are taken on time.
8. When complete remove each sample tube and allow the sample in the tube to run into the bottle.

After Bench Testing

After bench testing be sure to rinse all Aqua Monitor external surfaces with fresh water to avoid any damage due to chemical corrosion.

At this point the bench testing is complete.

Weight and note the filled weight of each bottle

You should have the following data.

1. The weight of each dry sample bottle
2. The total weight of each filled sample bottle

Calculate the weight and then volume of each sample. Tabulate the data and calculate the mean and variance of the samples. Your variance should be less than +/- 1% for all samples.

6.2 Preparation

Prior to performing sampling the user must prepare and install the sample bags. Bags of various volumes are available from 30 ml to 1000 ml. Each bag may be pre-dosed with preservative depending on the type of sample collected.

Numbering bags

To avoid sample confusion the sample bags should be permanently numbered before installation. Take care as some "permanent" markers are not permanent in seawater. It is also advisable to number the valve end of the sampling tubes.

Sample box installation

Install the numbered bags in the sample bag boxes. Please see the Deployment Frame section for details. Once the bags are installed in the boxes they should be loaded into the frame.

Pre-dosing preservatives

Each bag may be pre-dosed with preservative. The user is responsible for calculating the concentration of preservative needed. Typically the preservative will be injected into the bag via the entry tube or the valve connection tubing using a micro-pipette or plastic syringe.

Deep deployments (more than 100 m)

For pressure balanced (oil filled) versions of Aqua Monitor, in order to keep the whole system pressure balanced it is important to prime the sample bags prior to deployment. The bags need to contain sufficient fluid to fill all of the tubing (usually about 50 ml) before deployment to enable pressure balancing of the bag and tube. This would typically be a preservative or de-ionized water.

Bag connection

Once the sample bags are dosed with preservative (if needed) they can be attached to the valve nozzles. Take care to connect the bags to the valve nozzles in sequence.

Configuration

Plan your deployment in advance and determine your sampling regime.

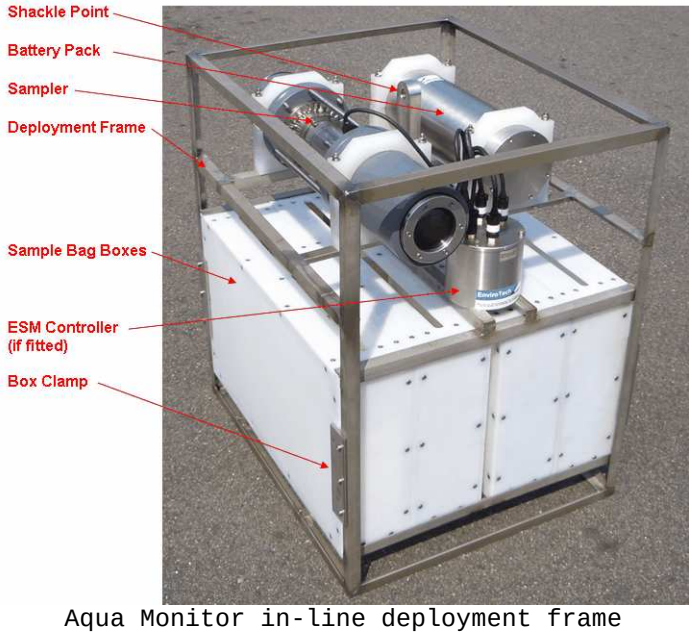
6.3 Deployment Procedure

Deployment Frame

A stainless steel deployment frames are available from EnviroTech Instruments LLC.

In-line deployment frame

The frame is made from heavy gauge material with a tie bar designed to take a through load or be attached to a mooring line. The deployment frame includes clamps for Aqua Monitor.



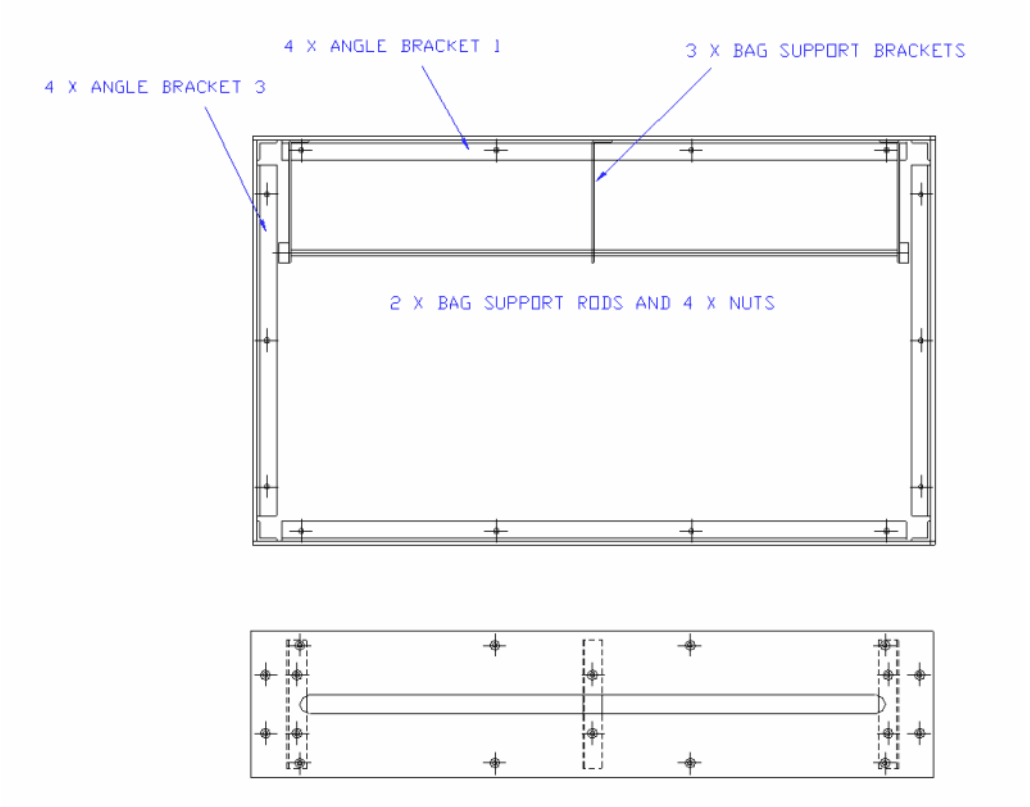
Aqua Monitor in-line deployment frame

Sample bag boxes

Sample bag boxes are supplied with the mooring frame. Your frame should be ordered with the appropriate boxes of the samples bags you wish to use. Bag sizes range from 250 ml to 3000 ml (although 1000 ml is a practical limit for the bag volume).

The boxes house and protect the sample bags. Each bag is hung from two support rods that run through the box end walls and secured by a knurled nut at each end. The support rods are in turn held in place and supported by three support brackets. The bag tube passes through a slot in the top of the box.

To install or remove the sample bags the top row of screws on the side and ends of each box should be removed leaving the angle brackets and support brackets attached to the lid. Then lift the lid off the box to expose the sample bags.



Sample bag box

Bottom deployment frame

For shallow water applications or bottom deployments a pyramidic deployment frame is available. This is made from heavy gauge stainless steel with anchor points for additional ballast, ground lines and marker floats.

Custom frames

Custom designed frames are available on request.

6.4 Checklist

Immediately before deployment Aqua Monitor should be prepared as follows:

- Set the deployment parameters
- Remove the communications cable and power lead
- Insert the communications dummy plug

- Place Aqua Monitor and battery pack in the deployment arrangement and secure all fixing plates
- Connect the battery pack lead to Aqua Monitor. Many users prefer to start the deployment while the instrument is in the frame.
- Deploy the assembly before the programmed delayed start elapses

There are a number of "classic" reasons for a failed deployment and human error is a significant risk. Before you deploy the instrument ensure that: the following items on your check list are complete and correct.

- The logging sequence and all variables and settings are recorded in your deployment log book
- The battery pack is connected
- Aqua Monitor clock is set accurately
- The instrument is verified to be in "logging mode"
- All necessary dummy plugs are inserted
- All brackets and fixings are tight (but not over-tight)
- All cables are secured by cable ties to avoid chaffing
- Sacrificial anodes are attached to the deployment frame
- All shackles are tight and locked
- Dissimilar metals are not in contact

Do not be rushed into allowing the equipment to be deployed until all the above points have been checked. If possible get a colleague to double-check.

During the actual deployment ensure that:

- Violent mechanical shocks are avoided
- The time the equipment enters the water is recorded
- The GPS position reading is recorded

A series of photographs of the equipment taken immediately before and during the deployment process often prove to be useful.

7.0 Recovery

As with the deployment procedure the recovery procedure for Aqua Monitor is highly dependent on the mooring design and facilities available. Aqua Monitor should be recovered carefully and avoiding unnecessary impacts or shock.

Immediately after recovery proceed as follows:

- Connect your PC and download the data from Aqua Monitor. If the battery is flat you may need a further external power supply.
- Remove power from the instrument by disconnecting the battery pack.
- Remove the sample bag tubes from the valve and clip them off
- Remove the sample boxes from the deployment frame
- Remove Aqua Monitor from the mooring arrangement
- The exterior of the instrument should be thoroughly washed with fresh water and dried to avoid corrosion.
- If post-deployment servicing is not going to be carried out immediately flush the valve and syringe through with deionized water or a mild solution of hydrochloric acid.
- Service Aqua Monitor

8.0 Consumables

In order to perform a successful deployment the user will require additional equipment and some standard accessories. These include samples bags, a battery pack, various cable ties, etc. Many of these items are included with Aqua Monitor when shipped, but replacements will be required for your second and subsequent deployments.

Consumables for use with Aqua Monitor are available from EnviroTech Instruments LLC. Some are available from alternative suppliers, in particular the preservatives.

In addition to sample bags following items are consumable and will require periodic replacement:

1. Sample tubing
2. Luer locks
3. Valve o-rings
4. Shaft o-rings
5. Battery pack

Aqua Monitor uses either the internal battery or an external power source. An external supply may be provided by a standard BBP-10 (250 m) or BBP-11 (4000 m) battery pack. The battery pack are constructed of primary cells (non-rechargeable). Rechargeable and custom solutions to increase sample frequency or deployment length can be supplied to special order.

9.0 Servicing

9.1 Maintenance

Aqua Monitor incorporates moving parts and must be properly maintained in order to ensure correct operation. The particular areas requiring maintenance are:

- The plunger seals
- The rotary valve and seals
- The control valve (if fitted)
- The linear shaft bush and seals
- The underwater connectors
- Main pressure case seals.

After each deployment Aqua Monitor should be thoroughly cleaned and the valve and syringe assembly serviced. The component parts must be stripped, cleaned, inspected and reassembled. The servicing frequency will be dependent on the operating conditions, especially the suspended solids concentration but as a guideline it is suggested that the valve and syringe assembly is serviced after every (48 sample) deployment at the very least.

NOTE: It is important that all o-seals and their sealing surfaces must be in perfect condition, scratch free and absolutely clean. Other than the valve seals plunger o-rings all seals should be lightly lubricated with silicone grease before assembly. This is essential to ensure complete watertight integrity.

All replacement parts, including o-seals, should be obtained from EnviroTech Instruments LLC.

Please see the service routines for specific service instructions.

9.2 Torque Settings

The table below gives torque settings for various components and fasteners.

Component	Torque setting
Barbed adapters on PEEK valve (light brown)	30 cNm (42 oz in)
M6 screws on valve plate	2 Nm (1.47 lbf ft)
M5 set screw on rotary shaft	2.5 Nm (1.84 lbf ft)
M6 screws on pressure housings	1.8 Nm (250 oz in)

9.3 Service Routines

Service Schedule

It is recommended that you keep service records in a log book and carefully record the service history of your instrument.

Oil Filled Systems

The 4000 m rated Aqua Monitor systems are oil-filled to pressure balance ......

Draining the Oil

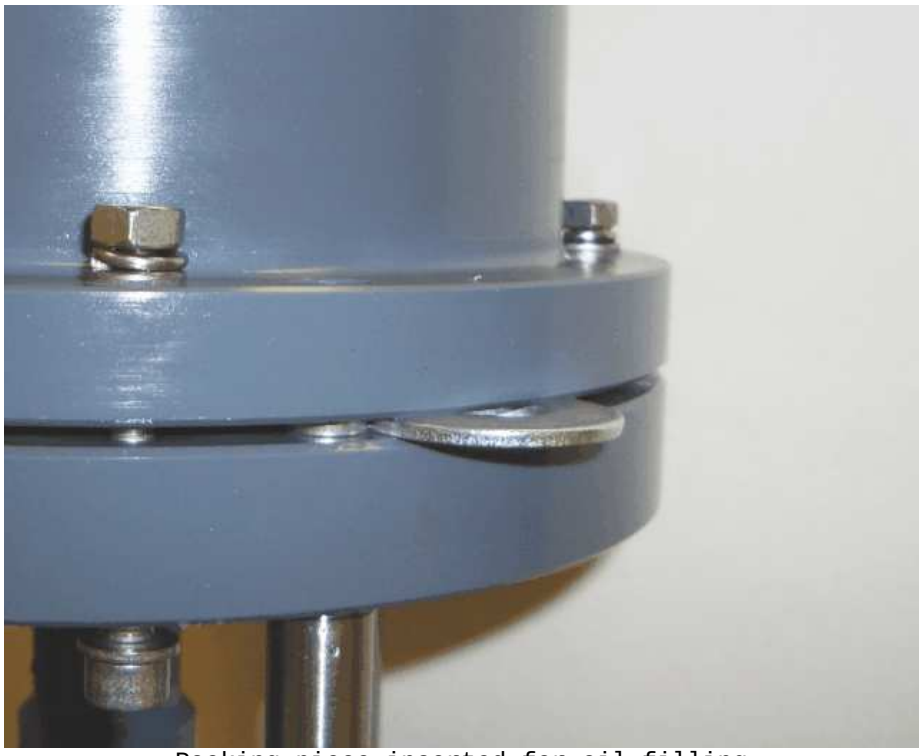
Loosen (but do not take out) the main housing bolts and gently press the diaphragm to separate the housing from the bulkhead. Insert 1.5 mm thick spacers as shown below. Tighten the bolts lightly on the spacer. Now carefully remove the diaphragm plate on top of the valve assembly. Tip out the oil into a suitable receptacle. If the oil is clear and in good condition in may be reused. Drain the syringe housing in a similar manner, but into a separate container (to avoid contamination).

Oil Filling

This is a critical operation. ***If not carried out correctly it can result in severe damage to the unit.***

Once drained and dismantled the unit should be re-assembled and oil filled as soon as possible to minimize the amount of oil drained from the motors, etc.

When re-assembling the rotary drive case, leave out the case fixing screws and jack the case away from its bulkhead by using pieces of packing 1.5mm thick.



Packing piece inserted for oil-filling

Fill the case with Dow Corning DC200/50 oil through the diaphragm hole. Leave for a few hours if possible to allow trapped air to escape.
Top up to fill, level with the top, and fit the diaphragm.

Now remove the packing pieces, push the case home and fit the bolts. This will put a positive pressure on the diaphragm

Properly pressurized valve diaphragm

The process for the linear drive case is the same except that the packing pieces should be doubled to 3mm thick.

Properly pressurized syringe diaphragm

The cases should now be pressurized hydrostatically to 20 bars (290psi) for at least 30 minutes to force oil into any unfilled cavities and the above process repeated if the diaphragms have lost pressure. (A small temporary loss of pressure may occur due to thermal contraction of the oil)

The cases should then be pressurized to the full working pressure and the diaphragms again checked for loss of pressure

The volume of oil required to fill both cases is a little less than 5 litres

9.4 Syringe

To service the syringe & plunger

1. Retract the plunger 2000 steps from fully home
2. Disconnect the power
3. Remove the cable clamp (if fitted)
4. Disconnect the interconnecting cables
5. Separate the rotary drive housing from the pillars by unscrewing the 3 x M6 socket cap screws
6. Carefully pull the rotary assembly away from the plunger

Clean the entire syringe plunger and cylinder assembly. Remove the syringe cylinder if necessary (recommended). Take care not to scratch the cylinder. Do not user solvents to clean the syringe or plunger.

Clean the plunger. Disassemble further if needed.

Carefully examine the seals and replace if necessary. Look for signs of debris on the seal and scratches on the sealing surface.

If the o-rings in the syringe require replacement:

1. Remove the screws from both ends of the syringe cylinder after marking the orientation as above
2. Pull the cylinder from the piston, replace the two o-rings and re-assemble

9.5 Valve

Each adapter nozzle is sealed by an o-ring between its flat end face and the flat-bottomed threaded hole in the valve body. The rotor uses o-rings to seal between the inside surface of the valve body and the rotor. After several standard deployments

(48 samples of 200 ml) these may wear and require replacement. To do this it is necessary to dismantle the valve using the following procedure:

1. Align the valve to port 1
2. Remove the 6 screws holding the syringe cylinder to the valve body and lift off the top half of the unit.
3. Mark the orientation of the valve body relative to the rotary drive housing using pencil marks or similar. Lift off the valve assembly without turning it.
4. Make pencil marks on the valve rotor and valve body so that they can be re-assembled in the same alignment.
5. Thread M6 screws into the tapped holes in the bottom of the valve rotor and use these to pull the rotor from the body
6. Remove and discard the o-rings from the rotor.
7. Clean all parts and fit new o-rings.
8. Push the rotor in to the body with the pencil marks aligned in the original position.
9. Refit the valve to the rotary housing in the original orientation
10. Slacken the valve adapters and re-tighten them to 30 cNm torque.
11. Re-assemble the complete instrument.
12. Check the valve alignment

The valve uses two types of o-rings:

Buna-N / Nitrile

-004 - Valve nozzles
-003 - Rotor seals

The rotor seals should be replaced periodically, every few deployments or when cross-talk is evident. The valve nozzle seals are static and do not require frequent replacement.

When the rotor seals have been replaced they should be run in. The recommended method is 4-6 consecutive align commands (G1). Then the system should be bench tested.

9.6 Valve Alignment

Port 1 Alignment

The G command aligns the valve to port 1. The position offset from the valve index may change slightly after servicing. Check the alignment. If it needs to be adjusted the configuration of the ELF-STEPPER must be updated. Open a connection to the stepper driver and modify the "o" setting. Increasing the argument will cause the valve to align more clockwise and reducing it more counter-clockwise. See Appendix B for command details.

See the Command Mode Definitions for full details.

Backlash

The ELF-STEPPER automatically compensates for backlash when the direction of the valve changes. With the correct backlash setting the valve may move port-to-port by the shortest distance and maintain its alignment. If the valve over or under-shoots after a change of direction it is possible that the backlash setting may need to be adjusted. Contact our technical support for advice before doing this.

9.7 Valve Nozzles

The torque of the barbed adapter nozzles on the rotary valve is critical to sealing. The nozzles must be tightened to at least 30 cNm. It is recommended that the valve nozzles are tightened with a micro torque wrench and the special nozzle adapter provided with Aqua Monitor. Over-tightening may cause damage or seizure of the valve and under-tightening will cause cross-talk resulting in variable results.

9.8 Syringe Motor

To access the syringe motor remove the lower pressure housing.

Lubrication

The linear syringe requires occasional servicing. It is lubricated prior to despatch. A small amount of this lubricant (black graphite grease) is included in the spares kit supplied. The lubrication of the lead screw should be checked periodically and grease re-applied as necessary. Retract the plunger fully and apply a pea-sized amount of grease to the lead screw immediately underneath the motor. Now run the motor in and out through its full travel five times.

Retaining bar

The horizontal "T-Bar" known as the Retaining Bar should be checked periodically for tightness and security. You should also ensure that the there is a 1 mm clearance between the top of the Retaining Bar and the rear of the syringe motor when the plunger is driven fully home.

9.9 Linear Shaft

To service the leaner shaft and seal:

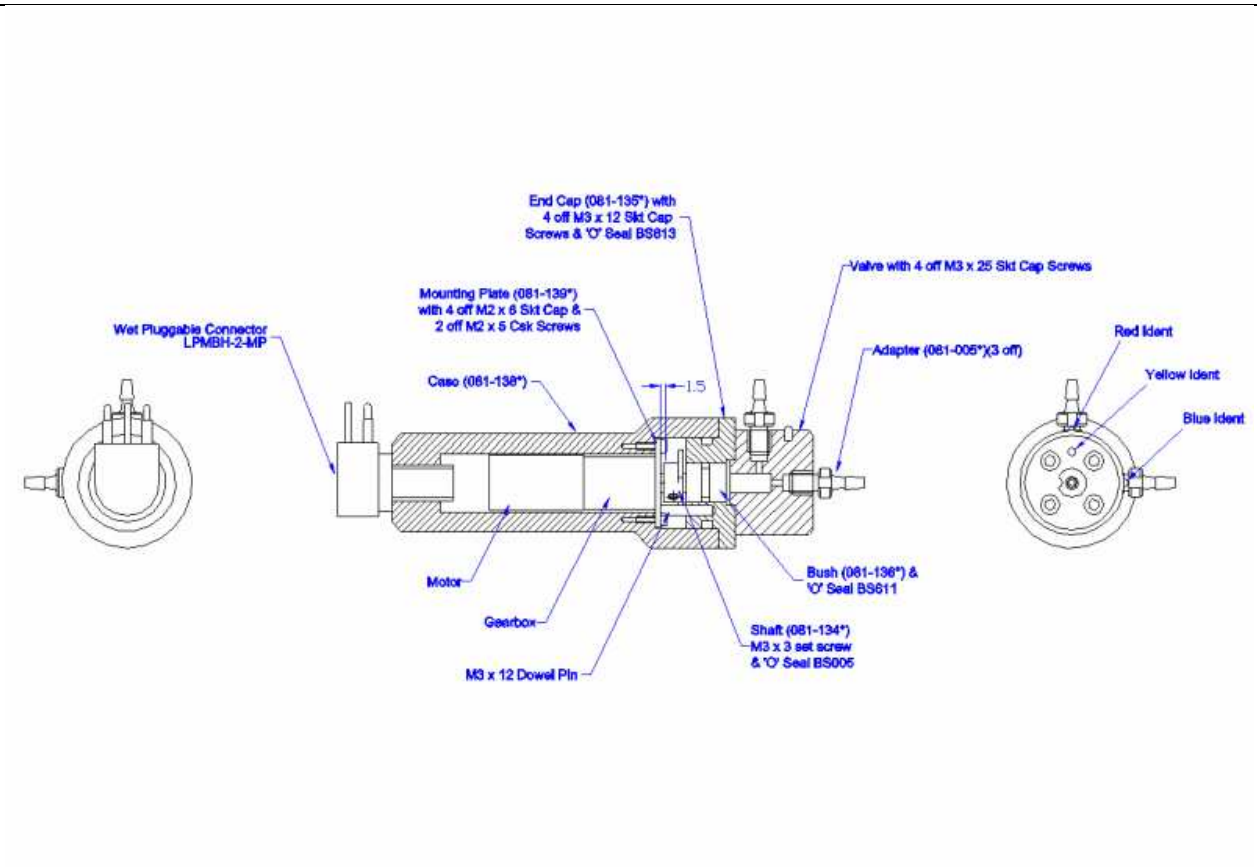
1. Unscrew and withdraw the linear drive bush leaving the shaft in place.
2. Carefully prise out the Variseal seal using a non scratching tool
3. Unscrew the shaft
4. Clean all parts and examine the bore of the bush carefully. It must have a good finish, free from scratches
5. Replace the o-seals and Variseal seal using the special tool.
6. Lubricate the shaft liberally with silicone grease before re-assembly
7. All items may now be re-assembled

9.10 Switching Valve

The switching valve may be tested using the "open" and "close" scripts. Blow through the valve in each position to ensure correct switching. If problems are encountered please check:

1. The motor is actually attempting to switch (listen for clicking and sliding noises)
2. The valve nozzle torque is correct and not too tight
3. Connector pins are clean and free from corrosion and discoloration
4. The valve is not worn and in need of replacement

The whole valve may be disassembled to perform further troubleshooting. A detailed diagram is given below. Please consult our technical support in case of problems.



disassembled

10.0 Spares

Aqua Monitor design incorporates moving parts. As with all moving parts they will eventually wear out. It is also recommended that some parts are periodically replaced in accordance with the servicing instructions (see the standard service schedule provided).

Please note that EnviroTech Instruments LLC offers a complete range of spare parts and a full instrument overhaul service. All spare parts and service are available via appointed distributors.

WMS-S005 - O-ring set

Inspect and replace as needed. Main pressure case seals should be cleaned and/or changed every major service.

WMS-S016 - Linear shaft

Linear Shaft - Regularly inspect for wear.

WMS-S009 - Linear bush assembly

Inspect and replace this assembly as necessary due to wear from suspended load. If leaking remove o-ring, clean groove and replace with new seal.

WMS-S015 - Lead screw

Lead Screw - Inspect for corrosion at top and regularly lubricate with graphite grease (black).

WMS-S017 - Seal housing & Variseal

Inspect and replace typically regularly (supplied assembled). Replace rear o-ring and clean sealing surfaces every inspection.

11.0 Firmware Upgrades

From time to time you may wish to upgrade the firmware in your Aqua Monitor. New versions of firmware are posted for download on our website. If you are known to us as a user you will also received email bulletins each time a new version is posted. Firmware is upgrade using a "boot-loader" program included with the update.

12.0 Returning Equipment

Before returning equipment for inspection, repair or service you must request a Return Material Authorization (RMA) number. Please email support@envirotechinstruments.com with details of your equipment and the return request.

Include the following information:

1. Your contact details
2. product/model
3. serial number
4. reason for return (e.g. repair)
5. description of the damage, defect or issue that requires attention

You will then be issued with an RMA sheet. Please put a copy of this sheet in the box when returning it.

We are committed to providing you with the best possible service. On receipt your equipment will be cataloged and inspected. Initially you will be sent a copy of our Equipment Receiving Record, followed later by an Inspection Report.

Unfortunately we are unable to accept items that are coated in anti-fouling paint for health and safety reasons.

Where possible and appropriate please include your deck-leads with the equipment so that we are able to perform a full system test.

You may request a status or progress report at any time using the ticket created by your original RMA request to support@envirotechinstruments.com.