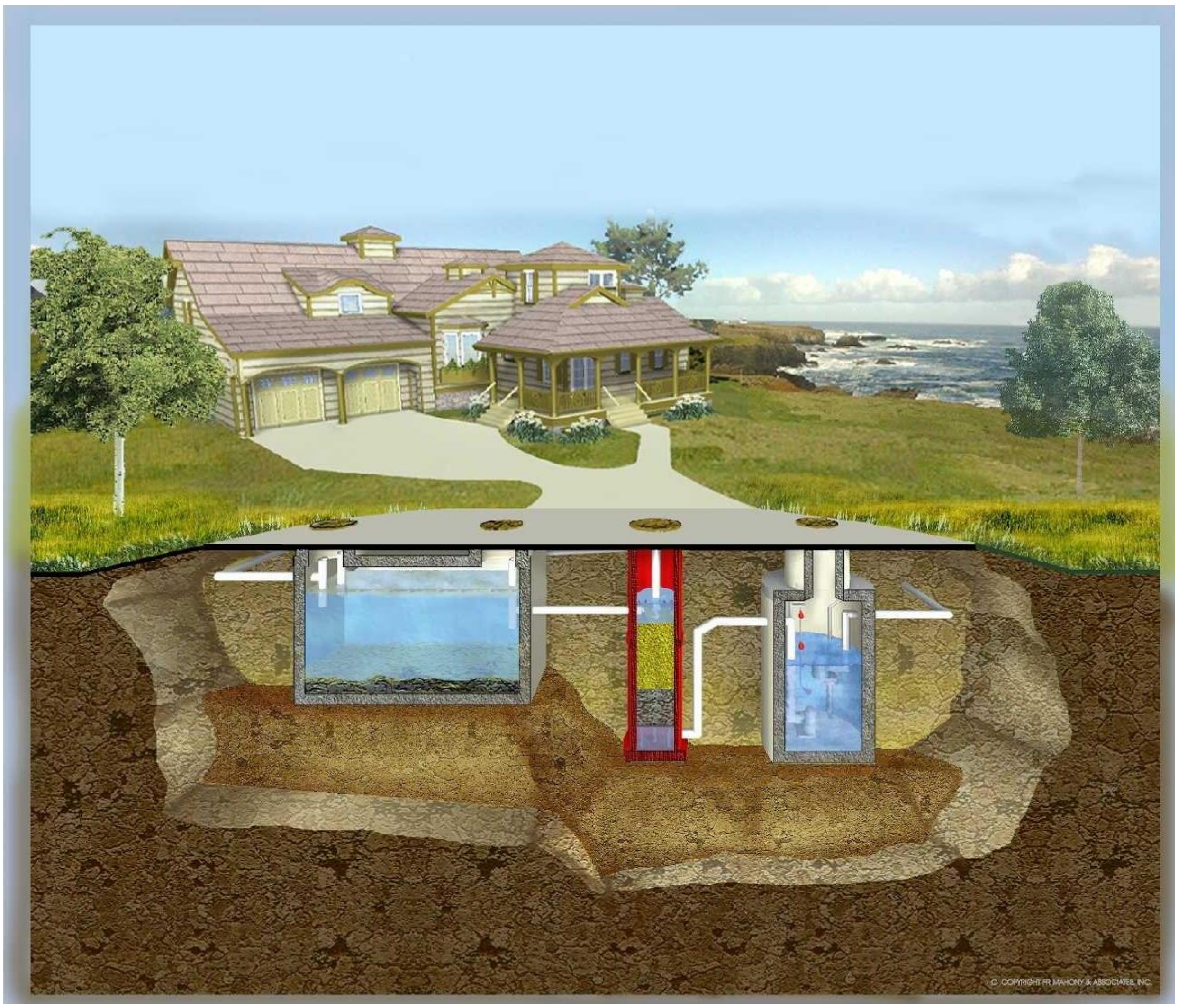
Amphidrome®

Operation & Maintenance Manual

June 2020

The highest level of Nitrogen removal available...



...and at a reasonable cost.

f.r. mahony & associates, inc.

frma

Revision 6/30/2020

1. FORWARD

This manual has been prepared to help meet the objectives of long equipment life, minimal equipment maintenance, and cost-effective performance. This manual must be read and understood by those responsible for the operation and maintenance of an Amphidrome® Wastewater Treatment System. Non-recommended, or unauthorized operating or maintenance procedures may result in damage to the equipment, down time, substandard treatment, and voidance of any warranties. Included in this manual is a brief summary of biological nutrient removal, a description of the Amphidrome® process, and a detailed description of the control programming. Operation and maintenance procedures for all of the equipment used in an Amphidrome® system are also included. The specific manufacturer's literature should always be referenced when performing any maintenance or troubleshooting. This manual should be used in conjunction with the design or the "As-built" plans, when provided. All standard safety procedures must be observed.

If any special information, regarding the care and operation of the Amphidrome® Wastewater Treatment System, is desired, F.R. Mahony will furnish it upon request.

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2. Introduction

The removal of soluble organic matter (SOM) from wastewater was traditionally the primary objective of biological wastewater treatment. The removal of SOM occurs as microorganisms use it as a food source, converting a portion of the carbon in the waste stream, to new biomass and the remainder to carbon dioxide (CO_2) and water (H_2O). The CO_2 is released to the atmosphere as a gas and the biomass is removed by sedimentation, yielding a waste stream free of the organic matter.

Cultures of aerobic microorganisms are especially effective for waste streams, which have a biodegradable chemical oxygen demand (bCOD) ranging between 50-4,000 mg/l. To accomplish this task, treatment units were designed and operated to maintain a culture of heterotrophic bacteria, under suitable environmental conditions so that the bacteria utilized the organic carbon from the incoming waste stream. The biochemical unit operations were coupled with additional solid-liquid separations processes to remove the suspended and colloidal solids in the waste stream. The result was an effective method for the removal of both soluble and particulate organic matter from the waste stream.

However, since the discovery of the effects of eutrophication, the removal of inorganic nutrients from wastewater has become an important consideration, and has imposed additional challenges on the design of wastewater treatment plants. The two primary causes of eutrophication are nitrogen and phosphorus and a number of biological nutrient removal (BNR) processes have been developed to remove them. In seawater and in tidal estuaries, nitrogen is typically the limiting nutrient. Therefore, nitrogen discharge limits in coastal areas have been made especially stringent in recent years. Biological removal of nitrogen to very low levels is easily accomplished.

In domestic wastewater, nitrogen is present as ammonia (NH_3) and as organic nitrogen (NH_2^-) in the form of amino groups. The organic nitrogen is released as ammonia, in the process of ammonification, as the organic matter containing it, undergoes biodegradation. Two groups of bacteria are responsible for converting ammonia to the innocuous form, nitrogen gas (N_2). The completion of this process occurs in two steps, by completely different bacteria, and in very different environments. In the first step, nitrifying bacteria oxidize ammonia to nitrate (NO_3^-) in a process called nitrification. The bacteria responsible for nitrification are chemolithotrophic, autotrophs that are also obligate aerobes; therefore, requiring an aerobic environment. Chemolithotrophic bacteria obtain energy from the oxidation of inorganic compounds, which in the nitrogen cycle, are ammonia (NH_3) and nitrate (NO_3^-). Autotrophic bacteria obtain their carbon source from inorganic carbon, such as carbon dioxide. In the second step, denitrification, facultative, heterotrophic bacteria convert nitrate to nitrogen gas, which is released to the atmosphere. This is accomplished only in an anoxic environment in which the bacteria use NO_3^- as the final electron acceptor. The ultimate electron acceptor being nitrogen, as it undergoes a stepwise conversion from an oxidation state of +5 in NO_3^- to 0 in N_2. This process may be carried on by some of the same facultative, heterotrophic bacteria that oxidize the soluble organic matter under aerobic conditions. However, the presence of any dissolved oxygen will inhibit denitrification, since the preferential path, for electron transfer, is to oxygen instead of to nitrate.

Since biological removal of nitrogen is both possible and economically viable, many of today's wastewater treatment plants require the removal of both soluble organic matter and nitrogen. To achieve this requires: a heterotrophic population of bacteria, operating in an aerobic environment to remove the SOM; a chemolithotrophic autotrophic population of bacteria, also operating in an aerobic environment, to convert the ammonia to nitrate; and finally a facultative heterotrophic population of bacteria, to convert nitrate to nitrogen gas, but in an anoxic environment. Therefore, typical treatment plant designs approach the removal of organics and nutrients in one of three ways. The first method is to combine the aerobic steps, (i.e. SOM removal and nitrification), into one operation and design the anoxic denitrification process as a separate unit operation. The second method is to design three separate unit operations for each step. The third method is to design a sequencing batch reactor (SBR), which has both aerobic zones and anoxic zones. The type of technology utilized greatly influences the number of unit operations to reach the desired effluent treatment level.

Biochemical operations have been classified according to the bioreactor type because the completeness of the biochemical transformation is influenced by the physical configuration of the reactor. Bioreactors fall into two categories depending on how the biological culture is maintained within suspended growth or attached growth (also called fixed film). In a suspended growth reactor, the biomass is suspended in the liquid being treated. Examples of suspended growth reactors include activated sludge and lagoon. In a fixed film reactor, the biomass attaches itself to a fixed media in the reactor and the wastewater flows over it. Examples of attached growth reactors include rotating biological contactor (RBC), trickling filter and submerged attached growth bioreactor (SAGB), also called biological aerated filter (BAF).

During the last twenty years, different configurations of SAGBs have been conceived and modest advances in the understanding of the systems have been made. The advantages of biological aerated filters are that they may operate without a solids separation unit process after biological treatment and with high concentrations of viable biomass. Removal of sludge is usually achieved by backwashing the filter. In such bioreactors, the hydraulic retention time (HRT) is less than the minimum solids retention time (SRT) required for microbial growth on the substrates provided. This means that the growth of suspended microorganisms is minimized and the growth of attached microorganisms is maximized. The low hydraulic retention time results in a significantly smaller required volume to treat a given waste stream than would be achieved with either a different fixed film reactor, or a suspended growth reactor for the same waste stream.

3. The Amphidrome®Process

The Amphidrome® system is a BNR process utilizing a submerged attached growth bioreactor operating in a batch mode. The deep bed sand filter is designed for the simultaneous removal of soluble organic matter, nitrogen and suspended solids within a single reactor.

To achieve simultaneous oxidation of soluble material, nitrification and denitrification in a single reactor, the process must provide aerobic and anoxic environments for the two different populations of microorganisms. The Amphidrome® system utilizes two tanks and one submerged attached growth bioreactor, subsequently called Amphidrome® reactor. The first tank, the anoxic/equalization tank, is where the raw wastewater enters the system. The tank has an equalization section, a settling zone, and a sludge storage section. It serves as a primary clarifier before the Amphidrome® reactor.

This Amphidrome® reactor consists of the following three items: underdrain, support gravel, and filter media. The underdrain, constructed of stainless steel, is located at the bottom of the reactor. It provides support for the media and even distribution of air and water into the reactor. The underdrain has a manifold and laterals to distribute the air evenly over the entire filter bottom. The design allows for both the air and water to be delivered simultaneously, or separately, via individual pathways to the bottom of the reactor. As the air flows up through the media, the bubbles are sheared by the sand producing finer bubbles as they rise through the filter. On top of the underdrain is 18" (five layers), of four different sizes of gravel. Above the gravel is a deep bed of coarse, round, silica sand media. The media functions as a filter; significantly reducing suspended solids, and provides the surface area for which an attached growth biomass can be maintained.

To achieve the two different environments required for the simultaneous removal of soluble organics and nitrogen, aeration of the reactor is intermittent rather than continuous. Depending on the strength and the volume of the wastewater, a typical aeration scheme may be three to five minutes of air and ten to fifteen minutes without air. Concurrently, return cycles are scheduled every hour, regardless of the aeration sequence. During a return, water from the clear well is pumped back up through the filter and overflows into the return flow/backwash pipe. A check valve in the influent line prevents the flow from returning to the anoxic/equalization tank, via that route. The return flow/backwash is set at a fixed height above both the media and the influent line; and the flow is by gravity back to the front of the anoxic/equalization tank.

The cyclical forward and reverse flow of the waste stream, and the intermittent aeration of the filter, achieve the required hydraulic retention time and create the necessary aerobic and anoxic conditions to maintain the required level of treatment.

4. Biochemical Reactions

The removal of SOM is achieved by the oxidation of carbonaceous matter, which is accomplished by the aerobic growth of heterotrophic bacteria. The biochemical transformation is described by the following normalized mass based stoichiometric equation in which the carbonaceous matter is a carbohydrate (CH_2O) and the nitrogen source for the bacteria is ammonium ($NH+_4$).

$$CH_2O + 0.309\ O_2 + 0.085\ NH^+_4 + 0.289\ HCO_3^- + 0.535\ C_5H_7O_2N + 0.633\ CO_2 + 0.515\ H_2O$$

The oxidation of ammonia to nitrate is accomplished by the aerobic growth of chemolithotrophic, autotrophic bacteria and is described by the following normalized mass based stoichiometric equation. The overall equation describes the two-step process in which ammonia is converted to nitrite by Nitrosifyers, and nitrite is converted to nitrate by Nitrifyers.

$$NH^+_4 + 3.30\ O_2 + 6.708\ HCO_3^- + 0.129\ C_5H_7O_2N + 3.373\ NO^-_3 + 1.041\ H_2O + 6.463\ H_2CO_3$$

The final step in the removal of nitrogen from the waste stream occurs when carbonaceous matter is oxidized by the growth of heterotrophic bacteria utilizing nitrate as the terminal electron accepter. The equation describing the biochemical transformation depends on the organic carbon source utilized. The following is the normalized mass based stoichiometric equation with the influent waste stream as the organic carbon source.

$NO^{-}_3 + 0.324\ C_{10}H_{19}O_3N + 0.226\ N_2 + 0.710\ CO_2 + 0.087\ H_2O + 0.027\ NH_3 + 0.274\ OH^-$

Biological removal of nitrogen has been the focus of much attention and many of today's wastewater treatment plants incorporate it. However, the difficultly in promoting these biochemical transformations in one reactor is the different environmental conditions required for each transformation.

This Amphidrome® process is designed to achieve the above reactions simultaneously within one reactor. The aerobic environment within the filter promotes the first two reactions. The return flow, to the anoxic/equalization tank, mixes the nitrates with organic carbon in the raw influent, and with organic carbon that has been released from the stored sludge. The anoxic environment within the filter promotes denitrification, the third reaction.

5. Wastewater Characteristics

The Amphidrome® process, like all wastewater processes, is designed to operate within design parameters of flow and wastewater characteristics. The first step to successful operation of any treatment facility is to characterize the wastewater through various analyses, which include: BOD, total suspended solids, settleable solids, COD, pH, alkalinity, DO, temperature, total solids, dissolved solids, nitrogen and phosphorus. Some of these parameters may not be specified by any imposed discharge limits; however, occasional sampling may prove prudent, should any problems arise. Maintaining a history of these analyses will prove helpful in following trends or anticipating changes in the treatment efficiency. Samples should be taken in the same locations and testing should follow "Standard Methods" or other approved regulatory testing procedures. Consistent techniques will provide more useful and valid information.

5.1. Wastewater Flow

Large fluctuations in wastewater flow may affect the treatment process; however, daily flows will fluctuate and should be expected. Major changes should be limited to the design capabilities of the treatment process. Wastewater flows may be monitored through water meter or pump run time. However, effluent flow metering is the most common and will provide an accurate measure of the flow actually processed at the facility.

Treatment plants are often designed based on expected flow rates from established literature, or from regulatory standards. These standards usually result in design flows that are greater than the actual flows. Once the facility is constructed, operating parameters must be set to treat actual flows; therefore, some adjustment may be required. Flows should not exceed the design permit flow.

5.2. pH, Alkalinity and Temperature

Typical domestic wastewater has a pH between 6.5 and 8.0. Biological microorganisms are affected by extreme variations in pH and in temperature. It has been shown experimentally that the reactions, of both nitrification and denitrification, are optimized at pH values in the range of 8. Therefore, it is recommended that supplemental alkalinity be used to maintain such a pH, as long as this does not put the plant in violation of any effluent limits. Maintaining such a pH will also insure that sufficient alkalinity is present for nitrification. The bacteria responsible for nitrification consume the inorganic carbon supplied by the bicarbonate dissolved in the wastewater. High bicarbonate alkalinity values indicate sufficient amounts for complete nitrification. Therefore, alkalinity is an important parameter in the monitoring treatment process in an Amphidrome® system. Two general rules may be used as operational guidelines: first, 7.4 mg/l of alkalinity is needed for each mg of ammonia to be nitrified, and second, a residual alkalinity value of 100 mg/l should be left after complete nitrification. Typically, both these conditions will be met if supplemental alkalinity is used to maintain the pH level at approximately 8.

Temperature fluctuations from weather conditions will have a minor affect on the Amphidrome® process because the process tanks are all underground and the air supplied during aeration is pumped. The pumped air is at a higher than ambient air temperature due to the pumping effects.

5.3. BOD, COD and Suspended Solids

Organic and solids loading are fundamental characteristics governing the size of treatment plant. BOD and COD are measures of the strength of the wastewater.

BOD (biochemical oxygen demand) measures the rate of oxygen uptake from the wastewater by microorganisms in biological reactions. These microorganisms are converting the waste materials to carbon dioxide, water and inorganic nitrogen compounds. The oxygen demand is related to the rate of increase in microorganism activity resulting from the presence of food (organic waste) and nutrients.

COD (chemical oxygen demand) measures the presence of carbon and hydrogen, but not amino nitrogen in organic materials. COD does not differentiate between biologically stable and unstable compounds. COD tests can be inhibited by chloride. Thus, wastewater containing high salt concentrations, such as brine, cannot be readily analyzed without modification.

The suspended solids parameter is a measure of the solids suspended in the wastewater. It is not a measure of the total solids which includes settleable and dissolved solids. The settleable solids are normally removed in the anoxic/equalization tank while suspended and dissolved solids are to be treated in the filtering and biological processes in the Amphidrome® reactor. As solids breakdown and are backwashed from the reactor, they settle and form a layer of sludge at the bottom of the anoxic/equalization tank. Periodic removal of the sludge is required.

5.4. Nitrogen

In domestic wastewater, nitrogen is present as ammonia (NH_3) and as organic nitrogen (NH_2^-) in the form of amino groups. The organic nitrogen is released as ammonia, in the process of ammonification, as the organic matter containing it undergoes biodegradation. To achieve biological nitrogen removal, bacteria must convert ammonia to the innocuous form, nitrogen (N_2) gas. However, the stepwise process produces nitrate (NO_3^-) as an intermediate compound. Nitrate in drinking water is of concern to infants because it has been linked to "methemaoglobinemia," which may result in death for infants. Monitoring of both ammonia and nitrate is extremely useful for process control and field testing should be performed at each maintenance visit.

6. Sampling

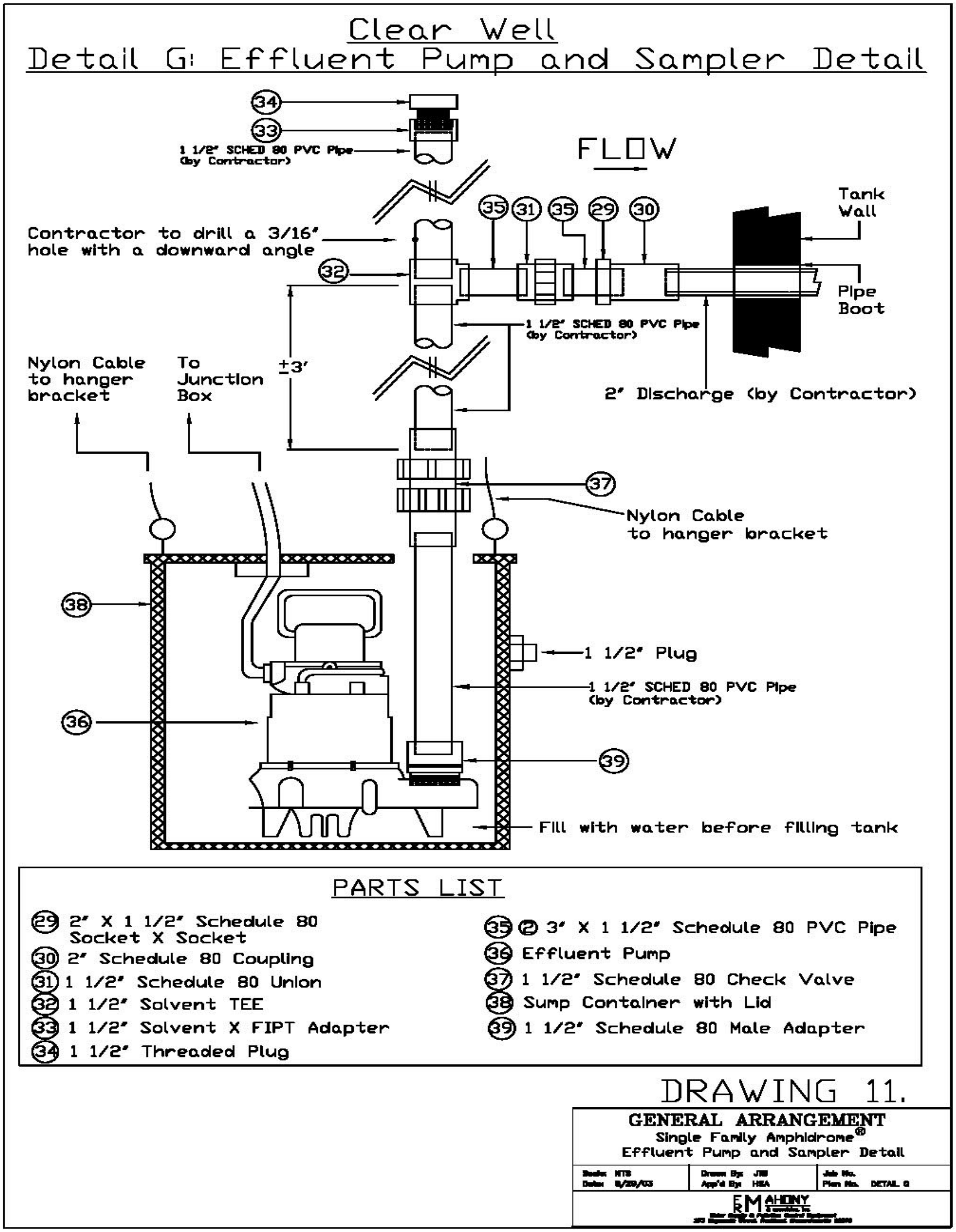
The primary objective of an Alternative Wastewater Treatment System is to meet the need of a particular permit level for treatment. Fundamental to that objective is reliable and accurate sampling and monitoring. In order to accurately assess the performance of the system, any entity operating an Amphidrome® Wastewater Treatment System must develop or follow a wastewater monitoring protocol for the collection, analysis and reporting of wastewater samples, which should include the following:

* Proper sample collection, storage and preservation,
* Proper sample tracking, analysis and reporting,
* Uniform application of approved analytical methods,
* Data reporting in useful and comparative format,
* Proper documentation of items influencing data quality.

6.1. Amphidrome® Sampler

The Amphidrome® system is a batch process that is typically set to discharge at the end of each 24-hour cycle. The effluent sampler will hold a sample from the most recent batch that has been discharged. The vertical discharge pipe is provided with a check valve above the discharge pump. The discharge pipe riser sample chamber will hold a minimum of 1000 ml of volume. The sampler and piping are shown in **Drawing 11, Detail G:** *Effluent Pump and Sampler Detail*.

The sample is drawn from the top of the sampler pipe by removing the manhole cover located at the discharge end of the clear well tank. A threaded plug must be removed from the top of the discharge sample pipe. A 1,000-ml disposable sample bailer is then inserted into the vertical discharge pipe and permitted to fill. The bailer device is provided with a check ball at the bottom to retain the sample when the bailer is removed from the sample chamber. The sample is then poured from the top of the bailer into an approved sample container with proper seal for handling and transport to an approved laboratory for analysis. The samples may be split as may be required for analysis.



DRAWING DETAIL G
EFFLUENT PUMP AND SAMPLER DETAIL

The sample chamber plug is threaded back in place and the manhole cover is replaced over the clear well access. The next discharge will flush the chamber and retain a sample for the next period of sampling. Thus samples may be drawn as often as required, but no more than once per batch.

6.2. Sampling Procedure

The manufacturer recommends that sampling procedures be in accordance with all sampling protocols for the location of the system. It is not the intent of the manufacturer to establish sampling protocols as each State or County agency establishes the sample and testing protocol for their region. At a minimum, proper sample handling and preservation techniques are required and "chain of custody" paperwork for each sample, with information regarding the sample location including full address, date taken, sampler, analyses to be performed and so forth.

All system operators performing sampling procedures are required to be familiar with local sampling protocols. The following is a suggested guideline:

1. All samples shall be collected in sample containers supplied by a certified laboratory. Sample containers shall contain laboratory prepared sample preservatives when applicable.

2. Samples should be collected directly into the containers in which they will be submitted for analysis. Where this is not possible, a dedicated disposable sampling device (e.g. polyethylene bailer) may be used, provided it is unwrapped immediately prior to use and properly disposed of after collecting the sample(s) from a single system. The sample collection device shall permit the use of approved sample collection device(s) mentioned above.

3. A laboratory supplied chain-of-custody and sample analysis request form shall accompany all sample containers and shall document the name of all individuals in possession of the sample containers, the time, date, and reason for the sample container transfer. In addition, the form shall be used to specify each sample analysis request (e.g. TKN, Nitrate-nitrogen, chloride, etc.), method of sample preservation, and shall document the time of sample collection, the point of collection, the method used to induce sample flow and any anomalous events and observations which occur during the sample collection.

4. All sample containers shall be pre-labeled prior to sample collection. Labels shall provide the location of the sample source with an identity corresponding to the engineering plan designation (PP1), parameter sampled, date and time of sample collection, samplers initials, preservative, and site name or location (e.g. street address).

5. All samples shall be collected and immediately placed in a laboratory supplied cooler and chilled on ice to 4°C. All samples shall be accompanied by a temperature blank supplied by the laboratory. The temperature of the temperature blank shall be determined by the state Certified Laboratory at the time of sample relinquishment. The laboratory shall record the temperature on the chain-of -custody and sample analysis request form.

6. All sample collection, storage, and transport procedures shall be in conformance with the state of the system proposed to be installed.

7. All laboratory analytical procedures shall be in accordance with the approving state guidelines.

8. All laboratory quality assurance/quality control procedures shall conform to the requirements of the regulations of the state the system is to be installed.

9. A sampling event, which results in non-compliance with effluent limitations, will result in consultation between the technology vendor. The vendor will be asked to describe measures which are being undertaken to troubleshoot the non-compliance. Re-sampling may be conducted to investigate potentially anomalous sample results.

7. Programmable Controllers

The Amphidrome® system is controlled by a programmable logic controller (PLC). PLCs are solid state members of the computer family that use integrated circuits instead of electromechanical devices to implement control functions. PLC's allow for the storing of instructions, such as sequencing, timing, counting, arithmetic, data manipulation, and communication, to control machines and processes.

The first programmable logic controller was specified in 1968, by the Hydramatic Division of General Motors Corporation. The requirements included, a solid state system with computer flexibility, the ability to survive in an industrial environment, be easily programmed, and be reusable. The early PLCs replaced the hardwired relay logic, which used electrically operated devices to mechanically switch electric circuits.

Programmable logic controllers today include many technological advances, in both hardware and software that have resulted in more capabilities than were ever anticipated. However, despite the level of sophistication in the design and construction, they still retain the simplicity and ease of operation that was intended in their original design.

7.1. Principles of Operation

A programmable logic controller consists of two basic sections, the central processing unit (CPU) and the input/output interface system (I/O). **See Figure 1**. The CPU consists of the processor, the memory system and the system power supply. It governs all the PLC activities. The I/O system is physically connected to the machinery (i.e. field

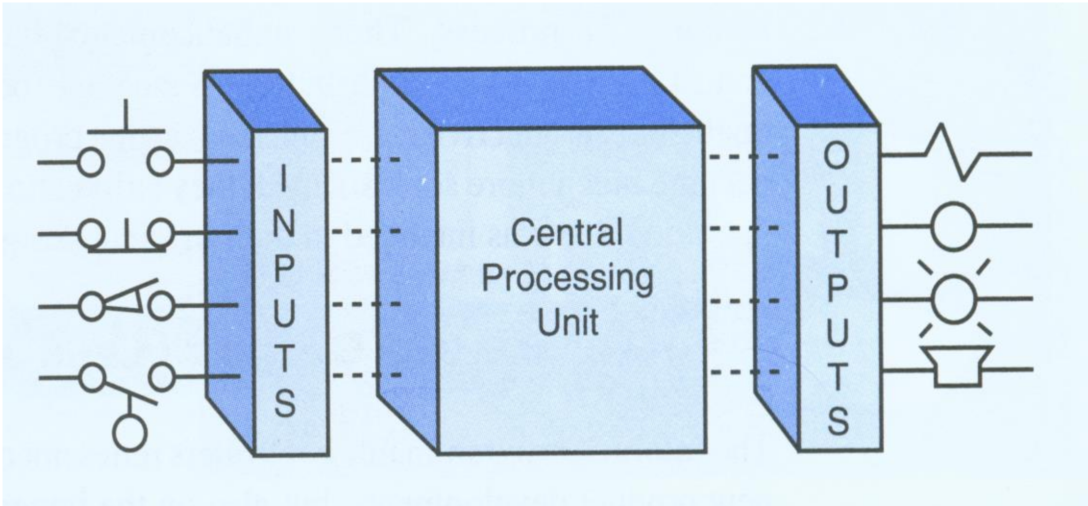


Figure 1. PLC Block Diagram

devices) used in the control of a process. The field devices may be discrete or analog input/output devices, such as limit switches, pressure transducers, motor starters, solenoids, etc. The I/O interfaces provide the connection between the CPU and the information provided by the inputs and the controllable devices (i.e. outputs, such as pumps or blowers). **See Figure 2**.

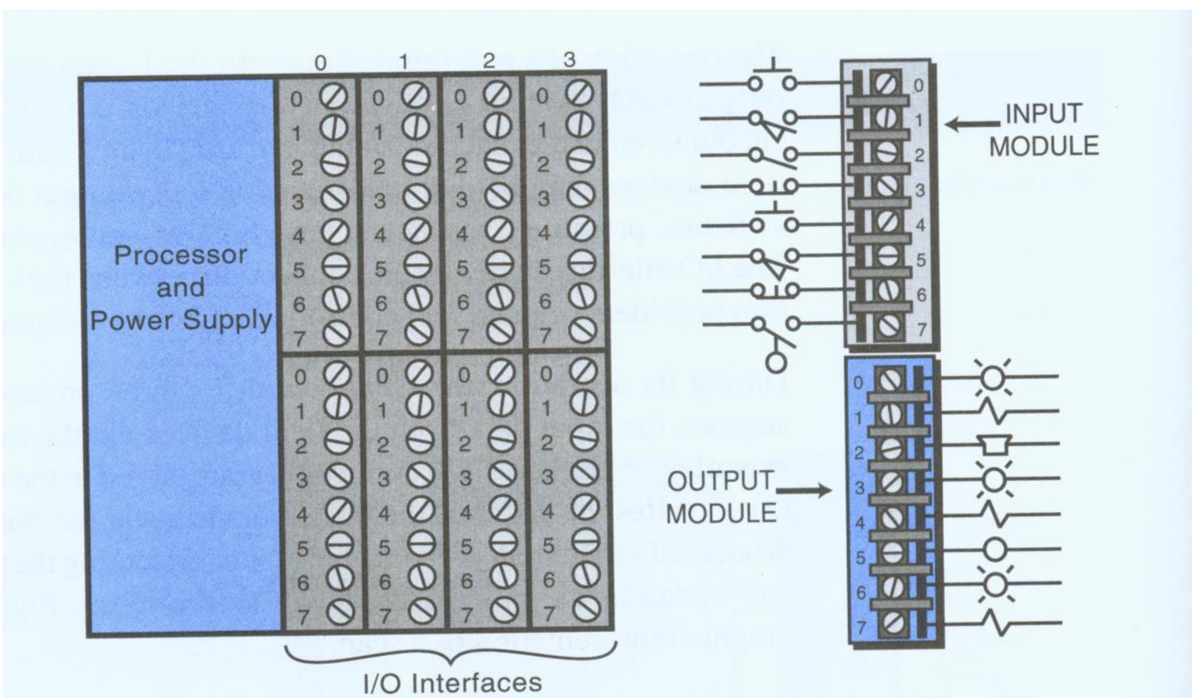


Figure 2. Input/Output Interfaces

During operation, the CPU does three things. First it reads the input data from the field devices via the input interfaces. Second, it executes the control program stored in the memory system, and finally, it updates the out devices via the output interfaces. The process of reading inputs, executing the program, and updating the outputs is known as scanning.

The input/output (I/O) section of the PLC acts as the interface to field devices and the CPU. Field sensing devices and controllers are wired to the I/O wiring terminals. The PLC power supply provides the necessary voltages for operation of the CPU and the I/O section of the controller.

Programmable controllers are available with either fixed or expandable I/O. Fixed I/O models, also referred to as "bricks", contain a fixed amount of I/O and are generally limited to about 20 or less I/O points in various configurations. Fixed I/O systems are well suited to applications with limited I/O requirements.

For systems with a large number of I/O points, expandable models are available. Expandable versions are modular in construction and consist of a rack or chassis containing a power supply and an assortment of I/O modules. The I/O modules are selected to meet the requirements of the various sensing devices and controllers used by the system. If the number of I/O points exceed the number of points that can be accommodated by a single chassis, further expansion is possible through the use of additional expansion racks.

Programming of a PLC is usually done with a personal computer or a manufacturer's mini-programmer, or "hand held programmer". All functions can be accomplished with either; however, it is more convenient with the computer. Programming and program changes refer only to modifications that affect the logic written into the program memory, not the operational settings that allow for optimization of the process.

8. The Amphidrome System and PLC Control Panel

9. The Amphidrome® System and Its PLC Control Panel

All Amphidrome® systems, typically employ PLC□**Direct™** by Koyo. This is a specific manufacturer's PLC hardware and software. Access to the main program logic is **not** possible, but access to all memory registers effecting the optimization of the process is possible. Thus the operator has a great deal of operational control over the process; however, in order to take advantage of this, a thorough understanding of both the Amphidrome® system and the biological processes involved is required.

To control the Amphidrome® process, the PLC continuously executes a 0 to 1440 minute cycle which corresponds to a 24 hour day. The time at which specific events occur during the process cycle, are controlled by entering values into memory location of the PLC referred to as V-memory registers. A listing of available V-registers with the associated function for each register is included with the Operation and Maintenance manual provided with the system.

As an example of how V-registers are used to control the process, assume that register V2200 has been assigned the function of initiating a backwash cycle and that the backwash cycle is to occur four hours into the cycle. The operator would load a value of 240 into register V2200, i.e. 4 hours x 60 minutes per hour = 240 minutes. If the system is set to reset to time zero at 5:00 AM, the backwash cycle would take place at 9:00 AM.

Access to the V-registers is through the hand held program loader (HP) shown in **Figure 4.** The HP connects to the PLC through the programming port using the cable supplied with the loader. The HP can be used to view the current status of all V-registers as well as changing the value of V-registers allocated for process control.

To view the status of any register, enter the following keystrokes on the HP:

SHFT, V, X, X, X, X, STAT

Where "X" is the number of the register to be monitored, the above keystrokes will display the current value of the selected register. Once a register is displayed, consecutive registers can be monitored through the use of the **prev** and **next** keys.

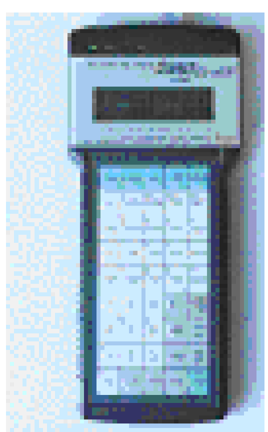


Figure 4. Hand Held Program Loader

Once a register is shown in the display, its value can be changed using the following keystrokes:

SHFT, K, #, #, #, #, ENT

Where "#" is the new value for the register, the new value for the selected register will now appear in the display.

9.1. Monitoring V-Memory Locations

The hand held programmer (HP) may be used to monitor and change V-memory locations. This is an especially useful feature, since almost all of the programmable controller's system data is mapped into V-memory. The following steps show how to monitor V-memory locations.

Press these Keystrokes

1. Select the location to monitor.

SHFT	V AND	C 2	A 0	A 0	A 0	STAT

HP Display Results

		V		2	0	0	1		V		2	0	0	0
				4	5	5	2				4	F	5	0

2. Use the PREV and NEXT keys to scroll through adjacent memory locations.

PREV	NEXT

HP Display Results

		V		2	0	0	1		V		2	0	0	0
				4	5	5	2				4	F	5	0

9.2. Changing V-Memory Values

Press these Keystrokes

1. Select the location to monitor.

SHFT	V AND	C 2	A 0	A 0	A 0	STAT

HP Display Results

		V		2	0	0	1		V		2	0	0	0
				4	5	5	2				4	F	5	0

2. Use K (constant) to load a new value in memory location V2000.

SHFT	K JMP	B 1	C 2	D 3	E 4

HP Display Results

		V		2	0	0	1		V		2	0	0	0
K	1	2	3	4										

3. Press ENT to enter new value.

ENT

HP Display Results

		V		2	0	0	1		V		2	0	0	0
				4	5	5	2				1	2	3	4

9.3. Features of the Single Family Amphidrome® Control Panel

1) The Amphidrome® system operates on a 0 – 1440-minute cycle.
2) All Amphidrome® filters have the capability of 16 backwashes.
3) The total number of discharges is recorded.
4) The total number of backwashes is recorded.
5) The total number of failed backwashes is recorded.
6) All submersible pump total run times are recorded.
7) Total run times for both the process blower and backwash blower are recorded.
8) A counter to track failed backwashes
9) A counter to track discharges by the clear well high level
10) A counter to track clear well high level alarms
11) A counter to track filter high level alarms
12) The panel interface is provided for field connection of modem to transmit operating data to FRMA home office for diagnostic analysis and emergency trouble shooting.

10. Automatic Voice/Pager Alarm Dialer System

The voice/pager alarm dialer system is used to transmit high clear well or filter high level alarms to one or more remote locations. The dialer features busy line and no answer detection to ensure prompt transmission of a prerecorded message, delivered sequentially to as many as four standard telephones, cellular telephones, voice and/or numeric pagers.

The dialer is fully programmable, offering personalized customization for each individual project. Programming options include but are not limited to:

- Store up to four telephone/pager numbers.
- Choose 1 to 9 calling efforts for the numbers dialed.
- Select 1 to 3 message repeats.
- Voice record an outgoing message in any language.
- Program voice messages to telephones and numeric code to pagers.
- The dialer will report weekly to FRMA's Rockland, MA office to insure that it is in operation.

The voice pager/alarm dialer is a stand alone unit operating 24 hours per day. Monitoring fees are not required.

11. Amphidrome® Control System

11.1. Cycle Control

The 24 hour Amphidrome® cycle is controlled by a 0 to 1440 minute counter CT0 in the programmable controller (PLC). This counter is reset by the internal clock/calendar of the PLC. Two V-registers are allocated for entering the desired time in hours and minutes for resetting the system to time zero.

In addition to the 24 hour counter, the program also includes a day of week counter in the PLC for selecting the days that backwash and discharge cycles will occur. The day of the week counter is CT30 and is advanced by 1 when the external 24 hour clock is activated.

The day of the week can be viewed in register V2006.

11.2. Backwash Cycle

The system is capable of 16 backwash cycles per day and backwashes can be set to occur on any or every day of the week. V2160 through V2166 are provided to enable\disable backwash cycles on Sunday through Saturday respectively. Backwash cycles are enabled for the day if the associated register for that day is set to a value of 1. If backwash cycles are disabled for any particular day, all backwash cycles for that day will be disabled.

Registers V2140 through V2157 are provided for setting the time to backwash for backwash cycles 1 through 16.

For the remainder of the description on control of the backwash cycle we will assume that registers V2160 through V2166 are set to 1 enabling backwash cycles for every day of the week.

Entering valid times into the backwash cycle control registers does not mean that all backwash cycles will occur daily.

Backwash cycles 1 through 16 are enabled automatically by the (PLC) logic depending on the amount of incoming flow. A measure of the incoming flow is how long it takes the system to return flow to the 2nd float in the clear well. A counter in the PLC (CNT20) records how long it takes for the system to return to the 2nd float. This counter is automatically reset to zero at the beginning of any return flow cycle. If the time to return to the 2nd float for the current cycle is greater than the time for the previous cycle the value in register V2250 is updated to reflect the longer return time. Register V2250 always contains the longest time to return to the 2nd float for a given day and is used to select the number of backwash cycles required for the next day. The value in V2250 is recorded and stored in register V2307 at the beginning of a new day for use in selecting the number of backwash cycles for that day. Once the previous days value is loaded in V2307 register V2250 is reset to zero and set to record the longest time to return to the 2nd float for the new day.

Note: If any return flow time is terminated by the high float in the filter before the system has returned to the 2nd float in the clear well the recorded value in CNT20 and V2252 will be equal to the total return flow time for that cycle.

If the system has discharged to the 2nd float in the clear well and there is not enough flow to elevate it again, there will be no backwash cycle for the following day. If flow is sufficient to elevate the 2nd float, but, not enough to cause the time to return to the 2nd float to be more than 1 minute, backwash cycles 1, 2, and 3, will take place.

The next 13 backwash cycles are selected based on the value stored in V2400 which represents the longest time to return to the 2nd float for the previous day.

If V2400 is equal to or greater than 1 minute backwash cycles 4, 5, and 6 are enabled.

If V2400 is equal to or greater than 2 minutes backwash cycles 7, 8, and 9 are enabled.

If V2400 is equal to or greater than 3 minutes backwash cycles 10, 11, and 12 are enabled.

If V2400 is equal to or greater than 4 minutes backwash cycles 13, 14, 15, and 16 are enabled.

Once a backwash cycle is initiated it is controlled by the values entered in registers V2171 through V2174. Typical values for these registers are listed below:

V2171 - Time to start blowers for backwash - set for 1 minute

V2172 - Time to stop blowers for backwash - set for 11 minutes

V2173 - Time to start pump for backwash - set for 6 minutes

V2174 - Time to backwash over trough – 5 minutes

With the above settings the blowers will start 1 minute into the backwash cycle and run alone. At 6 minutes into the cycle the backwash pump will start and run with the blowers. At 11 minutes into the cycle the blowers will stop and the backwash pump will run alone until the high float in the filter is elevated for 5 minutes.

11.3. Return Flow Cycles

There are provisions for 16 return flow cycles. The times for these cycles are set in registers V2050 through V2067. The return flow cycles will be automatically locked out for ½ hour prior to a backwash.

Once a return flow cycle is initiated it will continue to run until the low float in the clear well drops out, or until the high float in the filter has been elevated for the amount of time entered in register V2250 (time to return after high float in filter).

11.4. Process Air Cycle

There are 12 adjustable process air enable\disable periods. Enable\disable times for the 12 cycles are set in registers V2020 through V2047.

The process air off time is set in register V2017 and is common to all 12 individual process air cycles.

The process air on time is automatically calculated by the PLC logic and is dependent to some degree on the position of the 2nd float in the clear well.

If the system has discharged to the 2nd float in the clear well and this float has not become elevated again due to a lack of incoming flow the process air on time will be equal to the value in seconds entered in register V2115.

If the system has discharged to the 2nd float in the clear well and the 2nd float has become elevated again because of incoming flow the on time becomes a calculated value based on the amount of time to return flow to the 2nd float in the clear well. This calculated value is automatically adjusted throughout the day and at any given time is the product of the longest time to return to the 2nd float in the clear well times a multiplier in register V2117 plus a fixed run time in register V2116.
An option to disable the process air blower during a return flow\backwash cycle is provided. If register V2114 is set to 1 the process air blower will automatically shut down during a return flow\backwash cycle.

11.5. Discharge Cycle

Discharge cycles can be set to occur on any or all days of the week by entering a 0 through 6 into registers V2070 through V2076. The numbers 0 through 6 represent the days Sunday through Saturday respectively.

To disable the discharge cycle for any given day set the value in the associated V register for that day to 9999.

If enabled, the discharge cycle will occur at the beginning of a new day when the clock resets the system. The discharge will be to the 2nd float in the clear well.

If at any time during the day, a high level condition should occur in the clear well the system will automatically discharge for 3 minutes or until the 2nd float in the clear well drops out regardless of whether or not the discharge cycle was enabled for that day.

If the clear well high level float does not drop out within 3 minutes a high level alarm will be activated.

11.6. Filter High Level Alarm

If the high level float in the filter is elevated for 20 minutes a high level alarm is initiated.

The high level alarm timer is disabled whenever the backwash pump is in operation.

11.7. Clear Well High Level Alarm

If the high level float in the clear well becomes elevated a discharge cycle will be initiated. If the high level condition is not corrected in 3 minutes the high level alarm will be activated.

11.8. Accumulated Run Times

The following run times are recorded:

Description	Seconds (0 to 3600)	Minutes
Effluent Pump	V2012	V2000
Backwash Air Blower	V2013	V2001
Backwash Pump	V2014	V2002
Process Air Blower	V2015	V2003

11.9. Event Recorders

The following events are recorded:

Clear Well High Level Alarm Counter	V2004
Backwash Cycle Counter	V2005
Day of Week	V2006

Time Into Cycle	V2007
Number of Discharge Cycles	V2011
Filter High Level Alarm Counter	V2107
Number of Times Clear Well High Level Float is Activated	V2106

Note: In addition to the above registers V2200 through V2227 record the longest return flow times for the previous 24 days. Register V2200 contains the most recent data.

12. Operational Scenario of The Amphidrome® System

To achieve simultaneous oxidation of soluble material, nitrification, and denitrification in a single reactor, the process must provide aerobic and anoxic environments for the two different populations of microorganisms. The Amphidrome® system achieves this by using two tanks and one submerged attached growth bioreactor whose process is controlled by a sophisticated PLC computer program. The following outline provides a description of the structural framework of any Amphidrome® system. The control details of each particular Amphidrome® configuration are described in the controls' section of the Forward and in the Controls' section of the O & M manual.

- All Amphidrome® systems are setup with the ability to return flow from the clear well to the anoxic/equalization tank sixteen (16) times per day. The cycle clock operates on a time of 0 – 1440 minutes. The returns are set up to occur every hour on the hour, (i.e. at times 0, 60, 120, 180,….).

- Typically, the systems are setup to treat in one batch per day.

- The programmable controller (PLC) includes an internal clock/calendar for control of the process cycle. Registers are allocated for setting the time of day in hours and minutes at which the cycle time will be reset to time zero. The PLC clock is adjusted and records time in the 24 hour format. Refer to the memory allocation sheet specific to the system to be adjusted for the registers assigned to this function. For example, assume that register **V2200** is allocated for setting the "hour to reset the cycle to time zero" and that the desired time for the cycle to reset to zero is 2:45 PM. Using the hand held loader, the operator would load a value of 14 into register **V2200** (2:00 = 14 hours) and a value of 45 into register **V2201**.

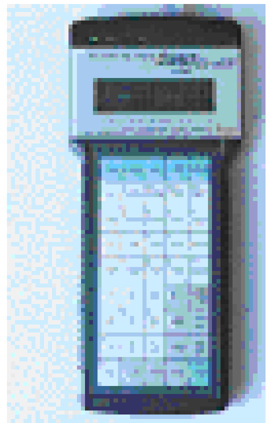


Figure 4. Hand Held Program Loader

12.1. Setting the Clock and Calendar

The **AUX 52** function allows you to set the Real-time clock and calendar using the following format.

- Date - Year, Month, Date, Day of week (0-6, Sunday through Saturday)
- Time - 24 hour format, Hours, Minutes, Seconds

If the date is changed without updating the day of the week (0-6), the CPU will not automatically correct any discrepancy between the date and the day of the week. For example, the date is changed to the 15th of the month and the 15th is on a Thursday. The day of the week will also need to be changed unless the CPU already shows the date as Thursday. Use the following example to change any component of the date or time settings.

Note: Verify that the clock and calendar is supported by your CPU before attempting to use this Auxiliary function.

Press these Keystrokes

1. Clear Complete Display Screen

CLR	**CLR**

HP Display Results

2. Select AUX 57

F 5	C 2	AUX

HP Display Results

A	U	X		5	*		C	P	U		C	F	G	
A	U	X		5	2		C	A	L	E	N	D	A	R

3. Select Date and Clock Display

ENT

HP Display Results

A	U	X		5	2		C	A	L	E	N	D	A	R
9	6	/	0	1	/	0	1	/	6	(	S	A	T	)

4. Enter New Date if Required

→	→	→	→	A 0	C 2

HP Display Results

A	U	X		5	2		C	A	L	E	N	D	A	R
9	6	/	0	1	/	0	2	/	7	(	S	U	N	)

5. To Accept Press ENT Twice

ENT	ENT

HP Display Results

A	U	X		5	2		C	A	L	E	N	D	A	R
T	I	M	E		0	0	:	0	6	:	0	0		

6. Enter New Time if Required

B 1	C 2	D 3	A 0

HP Display Results

A	U	X		5	2		C	A	L	E	N	D	A	R
T	I	M	E		1	2	:	3	0	:	0	0		

7. To Accept New Entry Press ENT Twice

ENT	ENT

HP Display Results

					9	**6**	**/**	**0**	**1**	**/**	**0**	**2**		
						1	**2**	**:**	**3**	**0**	**:**	**1**	**5**	

- The shaded area indicates cursor position.
- Press the CLR key to exit date and clock function.

Note: If the CPU is without power for an extended period of time a battery is required to maintain the proper date and time.

- Typically, at startup all aeration periods are utilized and the sequences are set up so that process blower fixed “on” time is 3 – 5 minutes and the process blower “off “ time is 10 – 15 minutes.

- The cyclical forward and reverse flow, of the waste stream, and the intermittent aeration of the filter, should be used in conjunction with one another to achieve the necessary aerobic and anoxic conditions required to meet the effluent permit requirements.

13. Operation

The Amphidrome® system is a submerged attached growth bioreactor (SAGB) process, designed around a deep bed, sand filter. The Amphidrome® system has all tanks located below grade with access hatches or manhole covers at grade level to allow for inspection and maintenance of the system. To ensure proper operation of the system, the operator must do inspection of the system internals.

13.1. Start Up and Initial Tests

Upon taking over operation of an Amphidrome® system, the operator should conduct three tests on each Amphidrome® filter in the plant. The tests are designed to determine the volume flow rates of water through the filters, one in the forward direction and two in the reverse direction.

13.1.1. Test 1: Forward Flow Test:

The purpose of the test is to determine the flow rate through the filter, (i.e. hydraulic loading). This test must be conducted at the end of an automatically scheduled return flow cycle or after a manually initiated return flow. After the return flow pump shuts off, the liquid level decreases in the Amphidrome® filter, and should be measured over equal increments of time until the forward flow slows down to less than a 1 inch change in ten minutes. During the first portion of the test in which the liquid level in the filter is high and the flow rate through the filter is also high, measurements should be taken every 1 –2 minutes. As the flow rate slows, down the measurements may be recorded every 5 – 10 minutes. The total time, total change in height, and the surface area of the reactor can be used to calculate the hydraulic loading. The data should be recorded on a table similar to that labeled *Filter Flow Through Rate*, and shown in Appendix 1.

13.1.2. Test 2: Return Flow Test:

The purpose of this test is to estimate the average volume flow rate for a return cycle. This value is necessary to control the amount of wastewater returned during each return cycle. This test must be conducted at the beginning of an automatically scheduled return flow cycle or at the beginning of a manually initiated return flow cycle. The level in the Amphidrome® filter should be low before the start of this test. After an initial measurement of the liquid level in the filter is recorded, the return flow pump should start, or be started. During the test, the liquid level in the filter should be measured and recorded every minute. Once the liquid starts to flow over the return flow/backwash trough, the test may be stopped. The total time to reach the trough should be recorded. The data should be recorded on a table similar to that labeled *Filter Flow Through Rate*, and shown in Appendix 1.

13.1.3. Process Control

Efficient operation and effective process control of an Amphidrome® System, as with any wastewater treatment plant, requires comprehensive methods for collecting and recording all pertinent information regarding plant performance and equipment maintenance. This is accomplished with an equipment log, a sampling and analysis plan for both the required sampling and all field sampling, and meticulous records of all observations regarding the daily operation of the plant. Examples of equipment logs are included in this manual.

13.1.4. Sample Collection

Since the Amphidrome® system is a batch treatment process, effluent samples must be collected at the end of each batch. Effluent sample devices furnished with this process are designed to capture the most recent discharge from the Amphidrome® system. A standpipe discharge pipe with check valve may be provided to hold a clean sample below the discharge pipe elevation. A removable threaded pipe plug is provided to access this standpipe to draw samples with a disposable sample bailer. The effluent or discharge pump should be in the "Off" position during this procedure. The individual taking the sample must be sure to replace the threaded plug and to put the effluent pump back in the "Auto" position before leaving the site.

The standard discharge line of 1-1/2 inch diameter will hold approximately 700 – 800 Ml of effluent sample. Samples must be drawn in accordance with New Jersey DEP guidelines by a trained and certified individual. Sample protocols must be followed to assure proper handling and "Chain-of-Custody" measures are followed. Effluent samples must not be collected from the anoxic/equalization tank since recycle to this occurs every hour.

13.1.5. Equipment Run Times:

All the equipment run times are recorded and stored by the PLC. These values are totals; therefore, the operator should record both the total time and the difference between the previous and the current readings, (i.e. the daily average). By averaging the daily run time of equipment it is possible to detect any potential problems and to verify that the equipment is operating for the approximate prescribed time in the program. For example, the process blower, daily average run time can be used to confirm that aeration is occurring, as programmed. Additionally, averaging equipment run time shows trends in the process. For example, the duration of the aeration is a function of the fixed air on time, and the flow based multiplier; therefore, aeration times vary with flow. Meticulous records of actual aeration times, which may be compared with the results of sample analyses, will allow for accurate process control decisions. **Recording of equipment run time is a critical and necessary part of operations and maintenance and should be performed diligently by the operator.**

13.1.6. Sludge Wasting and Sludge Removal:

Sludge wasting refers to the removal of sludge from the Amphidrome® reactor and is achieved by backwashing. Both the frequency and duration of the backwash is operator adjustable. Unlike an activated sludge system in which the amount of viable biomass within the vessel is controlled by monitoring the MLVSS, no such single parameter exists for monitoring biomass in a submerged attached growth bioreactor. Four parameters must be used to determine whether or not enough biomass exists: one, an effluent ammonia, (NH_3) analysis, two, the forward and reverse flow rates, three, the aeration pattern, and finally, both a visual and a laboratory analysis of the TSS in the backwash stream.

- The first parameter that is influenced by insufficient biomass is the ammonia level in the effluent. Therefore, if all the other factors affecting nitrification, (i.e. alkalinity, air, pH) are sufficient, and nitrification is incomplete the quantity of biomass within the filter must be suspect. In order to build a larger biomass, we want to reduce backwashes and ensure that process air is disabled during a return.

- A significant decrease in the forward and reverse flow rates from the original tests conducted by the operator, may indicate that the filter is plugging. This may be resolved by increasing the frequency and/or duration of the backwashes.

- The aeration pattern in the filter should be inspected with approximately 3 - 6 inches of water covering the media. **Even distribution of bubbles over the entire surface area should be observed.** Air bubbles that occur in separate discreet areas may indicate that the reactor is plugging or is plugged. In severe cases, air may be seen escaping several minutes after the blowers have been shut off. This may be resolved by increasing the frequency and/or duration of backwash cycles.

- Finally, to gauge the quantity of solids within the reactor, a sample at the beginning and ending of a backwash cycle should be collected and examined both visually and analytically for TSS. The first sample should be collected during a backwash just as the water starts to flow over the return flow/backwash trough. The second sample should be collected at the end of the backwash, just before the pumps shut off. Typically TSS values for the second sample range from 200 mg/l to 500 mg/l. However, it must be stressed that these numbers are typical, not absolute. Therefore, if a plant is meeting all discharge requirements with different values, than those specific values should be used for a guideline at that particular plant.

Sludge wasting is achieved by pumping stored sludge from the anoxic/equalization tank. The level of sludge within the anoxic/equalization tank should be checked quarterly when wastewater samples are collected.

13.1.7. Observation:

Several operational parameters may be determined by simple observation, which in conjunction with field-testing, can be extremely useful for process control. The Amphidrome® process should not have suspended solids in the effluent, nor should strong offensive odors be present in any of the tanks. Therefore, visual inspection of effluent turbidity and color may be an indication of process problems. It is recommended that along with the field sampling (i.e. test kit sampling), that the color and clarity of the effluent be noted in the operator's log.

Strong odors, indicating a highly septic environment, should not be present in the Amphidrome® system. Any odor present in any of the tanks should also be noted in the operator's log and should be investigated, as this indicates a potential problem.

14. Troubleshooting Guidelines

14.1. Equipment

14.1.1. Blowers

Problem	Possible Cause	Solution
No air supply to reactor, when called for OR	Blower not operating	Ensure blower switch is on. Check circuit breaker and reset. If breaker continues to trip have circuit checked by qualified technician
	Incorrect rotation	Check for proper rotation.
	Broken/missing drive belt	Replace belt
	Closed valve	Ensure correct valve is open Ensure check valves have been installed correctly and are working properly.
Low air supply	Blockage in air line	Check operating pressure clear blockage Check pressure relief for open or closed condition
	Broken air discharge line	Investigate for breaks in discharge line and repair
Blower does not operate or ceases to operate	Not called for	Check program to confirm blower should be operating
	Switch in the off position	Ensure correct switch is in the on or auto position
	Breaker tripped	Check circuit breaker and reset. If breaker continues to trip have circuit checked by qualified technician.
Blower running abnormally hot	Inadequate lubrication	Ensure proper lubrication – consult manufacturers lubrication instructions
	Low inlet air supply	Check inlet piping for blockage Check inlet filter(s) and replace if necessary

Blowers (cont'd)

Problem	Possible Cause	Solution
Blower running abnormally hot (continued)	Poor ventilation	Ensure adequate ventilation
High discharge pressure	Valve closed Obstruction in discharge line Check valve installed improperly, broken or stuck Reactor plugged Relief valve improperly set	Check valves Clear obstruction Inspect check valve Backwash (filter) reactor Adjust relief valve
Blower abnormally noisy	Improper lubrication Bearing noise (could be the blower or the motor) Belt hitting guard Loose belts, guards, etc. Valve closed	Ensure proper lubrication Replace bearings if necessary Adjust guard Tighten all equipment Check discharge valves

14.1.2. Submersible Pumps

Problem	Possible Cause	Solution
Pump will not operate	Circuit breaker tripped or switch in off position (If it continues to trip)	Check breaker. Reset if tripped. Check switch. Circuit should be checked by a qualified technician. If necessary, remove pump from tank and inspect
Pump will not operate in automatic	Switch not in auto position Low float not made	Check switch Check floats
Low flow rate	Improper rotation Valve partially closed Pump not seated properly Check valve stuck or clogged Discharge line clogged Discharge head too high Pump dirty or clogged Impeller spinning on shaft	Check rotation Check valves Check pump connections Inspect check valve and discharge line Review pump curve Check discharge head Remove pump from tank and inspect

14.1.3. Flow Sensor and Meter

Problem	Possible Cause	Solution
No display on screen	Circuit breaker tripped Improper wiring Meter malfunctioning	Check breaker and reset Have wiring checked by a qualified technician Replace meter
Improper flow rate and totalization	Meter programmed improperly Sensor malfunctioning or broken Incorrect sensor installation Pump malfunctioning	Consult manufacturer's literature for proper programming Remove sensor and inspect Consult manufacturer's installation instructions Troubleshoot pump
No flow rate or totalization	Sensor broken or clogged Improper wiring Pump off	Remove sensor, inspect and clean if necessary Check wiring Check pump

14.2. Controls

14.2.1. Floats

Problem	Possible Cause	Solution
Equipment not responding to floats	Bad wiring or connections	Check wiring and connections for complete circuit
	Improper float application (Normally open)	Make sure floats are correct for application
	Improper signal input location	Have qualified technician troubleshoot signal input at panel
	Bad float	Replace float
	Equipment not in automatic position	Check H/O/A switches
	Float hung up in improper position	Check float positions

Process Control

14.2.2. BOD Removal

Problem	Possible Cause	Solution
High effluent BOD	High organic loading	Check actual vs. design organic loading Investigate abnormally high influent organic loading. Increase number of returns and possibly decrease number of batches.
	Insufficient dissolved oxygen	Troubleshoot air supply system Increase air supply
	High hydraulic loading	Check actual vs. design hydraulic loading Investigate abnormally high hydraulic loading Increase number of batches Limit 2 / 24 hour period if possible
	Insufficient biomass	Decrease number of backwashes if possible Check BOD: N: P ratio
	Total suspended solids in effluent	Troubleshoot TSS problem
	Toxic material in influent	Investigate for toxins or biocides

14.2.3. TSS Removal

Problem	Possible Cause	Solution
High Effluent TSS	High influent TSS	Check depth of blanket in anoxic tank – if within two feet of bottom of outlet tee, pump out anoxic tank.
	Dirty Amphidrome® reactor	Increase backwash of Amphidrome®

14.2.4. Nitrogen Removal -TKN

Problem	Possible Cause	Solution
High effluent TKN	Insufficient D.O	Increase air supply either by adjusting the fixed or the multiplier
	High influent TKN loading	Check actual vs. design TKN loading
	Insufficient biomass	Decrease Amphidrome® backwash if possible Check BOD: N: P ratio
	Low return frequency	Increase number of returns if possible
	Toxic material in influent	Investigate influent for toxins or biocides
	Low pH and or temperature	Check pH and temperature of process

14.2.5. Nitrogen Removal – NH3

Problem	Possible Cause	Solution
High effluent ammonia	Insufficient dissolved oxygen	Increase air supply Troubleshoot air system if necessary
	High influent ammonia loading	Check actual vs. design ammonia loading Investigate abnormally high loading
	Insufficient biomass	Decrease backwash of Amphidrome® if possible Check BOD: N: P ratio
	Insufficient alkalinity	Check effluent alkalinity If less than 100 mg/l add sodium bicarbonate to system.
	Low temperature	Check temperature of process If abnormally low, investigate cause
	Excessively high return rate over trough	Check the return flow to influent flow ratio
	Toxic material present in process wastewater of influent	Investigate influent and process water for toxins and or biocides
	High hydraulic loading	Check actual vs. design hydraulic loading Investigate abnormally high hydraulic loading Increase number of batches to 2/24 hr. period maximum if necessary

14.2.6. Nitrogen Removal – NO3-

Problem	Possible Cause	Solution
High nitrate in effluent and fractional ammonia level	Excess dissolved oxygen in system	Decrease air supply and recheck both nitrate and ammonia Check anoxic tank, maintain anoxic conditions Check return flow volume to influent ratio, adjust accordingly (i.e. DO ≤ .5 mg/e)