AdvanTex® O&M MANUAL

PART 2: ADVANCED SERVICE TIPS AND TROUBLESHOOTING GUIDE

Part 2:
Advanced Service Tips and Troubleshooting Guide

O&M MANUAL

Orenco Systems®
Incorporated

Changing the Way the World Does Wastewater®

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Introduction

As an authorized AdvanTex® Service Provider, you play a crucial role in Orenco's AdvanTex Program.

Orenco has always advocated regular, professional servicing of all onsite systems ... not just during the warranty period but for the life of the system. Regular servicing optimizes the treatment process and protects the property owner's investment. It also ensures that onsite systems protect public health, protect the environment, and are viewed as a reliable, sustainable technology.

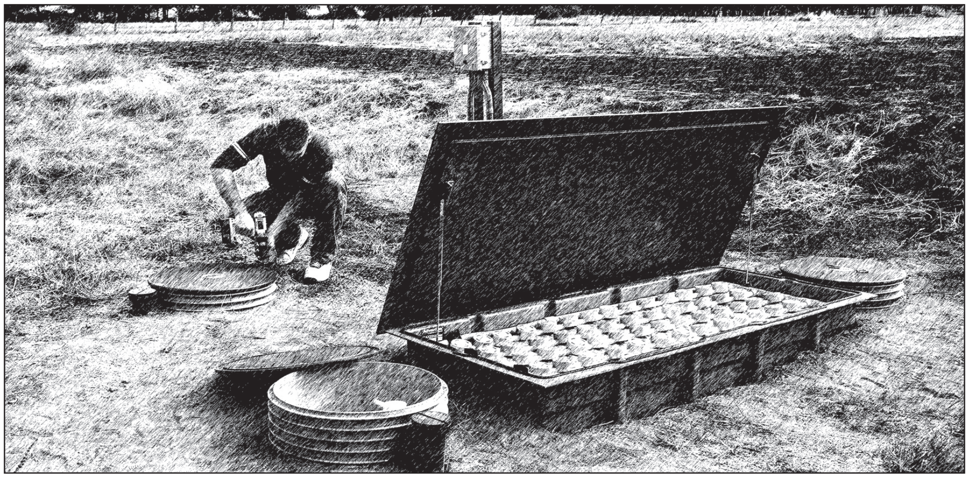
Orenco relies on you to perform the AdvanTex system start-up, do routine (scheduled) maintenance, and respond to calls for unscheduled maintenance (alarm calls). We also rely on you to keep in contact with the homeowners or property owners, review the *Homeowner's Manual* with them, advise them on preventive maintenance, and work to keep the system under a continuous service contract. Equally important, we rely on you to keep good service records on the system, creating a "history" of its performance.

To make your job easier, Orenco has created one of the most service-friendly and trouble-free onsite systems on the market. AdvanTex is a packed bed (media) filter. And media filters are the most suitable technology for onsite wastewater treatment because they are reliable and provide consistent, high-quality effluent. We then paired our media filter with a remote telemetry control panel, to allow you to "view" the system right from your computer. And we've provided a Web-based business tool — advantexservice.com — to help you file and retrieve system data automatically, schedule service events, and manage service technicians.

Finally, we've provided classroom and field training, as well as support materials, like this O&M Manual. Please read it thoroughly, and refer to it often.

We're very proud of our AdvanTex Treatment System. Like all our products, it has gone through extensive research, development, and field-testing. Then each component is built to written specifications and subjected to quality review, before shipping. In addition, our AXN models meet the requirements of NSF-ANSI Standard 40 for Class I Systems.

Thank you, in advance, for your knowledge, your conscientiousness, and your good work.



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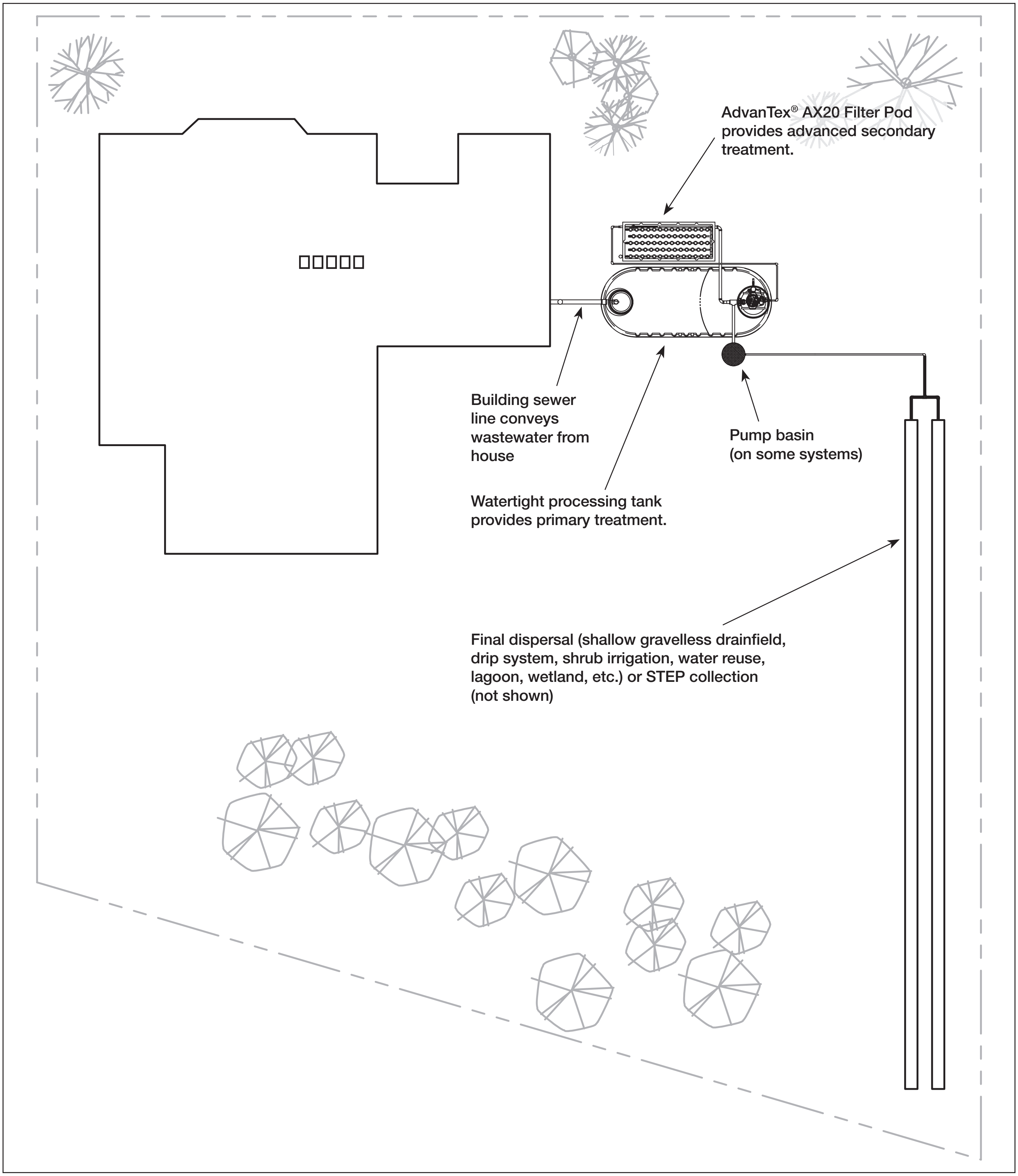
Typical Site Plan for an AdvanTex® Treatment System



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How the AdvanTex Treatment System Works

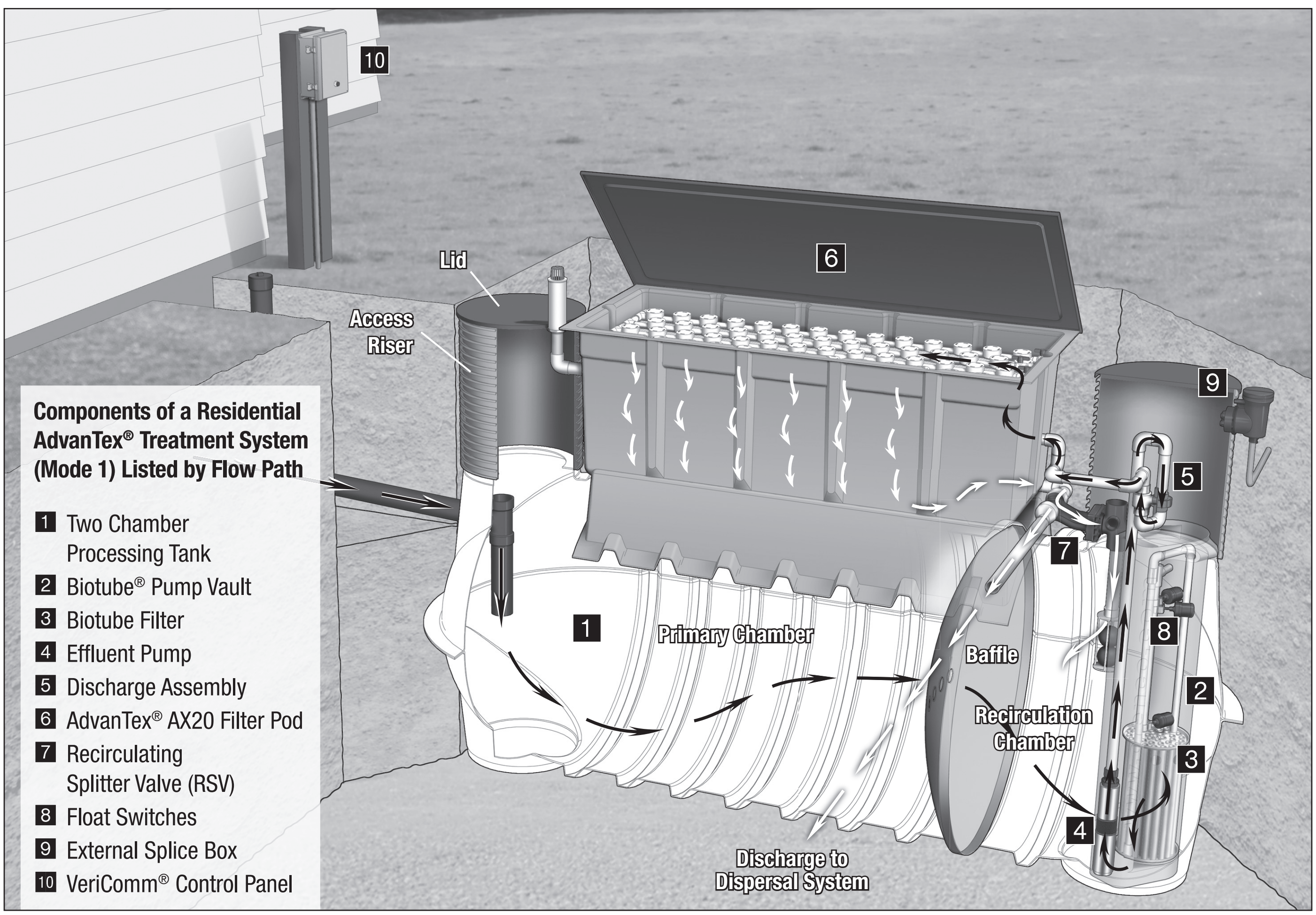
The AdvanTex Treatment System consists of a watertight processing tank and the AX20 textile filter pod. Wastewater from the home flows to the tank, where natural biological and physical processes provide primary treatment. In the primary chamber of the tank, the wastewater separates into three layers: a floating scum layer, a bottom sludge layer, and a relatively clear layer of liquid effluent in the middle.

From the secondary chamber, a pump draws liquid effluent through the Biotube® filter and sends it to the AX20 pod. There, the effluent is sprayed over hanging sheets of porous synthetic textile media. Microorganisms live in this moist, oxygen-rich (aerobic) environment. As effluent trickles over and through the sheets, the microorganisms break down the contaminants and eliminate them.

Effluent recirculates between the tank and the AX20 pod. In Mode 1, the most common configuration, the effluent recirculates to the second compartment of the tank. In Mode 3, effluent recirculates to the first compartment. This mode is used where maximum removal of nitrogen from the effluent is required.

After recirculating several times, the effluent is discharged, either directly from the processing tank or after first being collected in a pump basin. Depending on the design for a particular site, the treated effluent may be discharged to a drainfield, an underground drip irrigation system, a constructed wetland, an effluent sewer (STEP) system, or a reuse system. The system may include equipment for ultraviolet (UV) disinfection before ultimate dispersal of the effluent.

Properly designed, installed, and operated, a Residential AdvanTex Treatment System can treat wastewater to 5 mg/L BOD_5 and 5 mg/L TSS. This level of treatment is better than what municipal wastewater plants provide. The system can also be configured to reduce nitrogen levels as required locally. When effluent treated in this way is dispersed to the soil, natural processes purify it further, and it eventually returns to the underlying water table, where it can be used again.



Equipment List

Routine maintenance and troubleshooting require a variety of tools, equipment, and spare parts. We recommend that an Authorized AdvanTex Service Provider have the following items at hand:

For Routine Inspection and Maintenance

- Cordless drill with 3/16-in. Allen wrench for lid bolts on risers and pod
- Extra lid bolts
- Sludge and scum measuring device (e.g., Nasco Sludge Judge® for sludge and Orenco SMUG for scum)
- Hook for raising floats to test them
- Biotube® filter cradle (OM-BIOTUBECRADLE)
- Backpack pressure washer
- Trash pump (and generator, if pump is electric) for removing solids from discharge basin
- AX20 manifold brush (AX-LATERALBRUSH)
- AX20 sheet cleaning wand (AX-CLEANINGWAND)
- Handheld computer (PDA) with Bluetooth® Kit or laptop with null modem cable (optional, to turn pump on and off at a distance from the panel)
- Electrical tester (voltage and amperage)
- Phone line tester (available from RadioShack®)
- Dissolved oxygen (DO) meter or colorimetric ampoules
- Sample bottles with grab sample device
- Turbidity meter
- pH meter or pH test strips
- Test strips for nitrate, ammonia, alkalinity
- Tape measure
- Calculator
- A copy of the *AX20 Installation Instructions* (NIM-ATX-AX-1) and *AdvanTex O&M Manual Part:1 Start-Up and Routine Maintenance* (AIM-OM-ATX-1), for reference

For Repairs

- Adhesive (ADH100, SS140, SS115, SS845)
- Control panel parts (circuit breakers, motor contractors, relays)
- Effluent pumps
- Extension cord
- Flashlight
- Hand tools (pliers, wrenches, screwdrivers, drill bits, hammer, shovel, hand saw, etc.)
- Inspection mirror (e.g., Prototek "Mirror on a Stick")
- Plumber's snake
- PVC cement and primer
- PVC fittings (3/4 in. to 2 in.)
- PVC pipe (3/4 in. to 2 in.)
- Spare parts for downstream components (e.g. drip headworks, UV disinfection unit)
- Waterproof wire nuts
- Wire stripping/crimping tool
- Float switches

For Troubleshooting

- Digital camera
- Watch or timer
- A copy of Part 2 of the AdvanTex O&M Manual: *Advanced Service Tips and Troubleshooting Guide* (AIM-OM-ATX-2)

For Personal Hygiene and Cleanup

- Bleach/water solution
- Eye protection
- Hand cleanser
- Paper towels
- Protective clothing
- Rags
- Rubber gloves

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Factors Affecting the AdvanTex Treatment Process

Properly designed, installed, and operated, a Residential AdvanTex Treatment System can treat wastewater to 5 mg/L BOD_5 and 5 mg/L TSS. If treatment performance fails to meet that standard, the cause may be the design, installation, settings, or use of the system — or more likely, a combination of those factors. Here's what happens in each part of the system, and how each of these factors can keep the system from performing as well as it should.

Processing Tank

Primary treatment happens in the tank, and several conditions inside the tank affect the ultimate effluent quality. The first is the **incoming wastewater**: its strength (concentration), mass loading (amount of each wastewater component), hydraulic loading (volume), and chemical characteristics. Residential wastewater (raw influent) typically has BOD_5 of 450 mg/L, TSS of 500 mg/L, and total Kjeldahl nitrogen (TKN) of 70 mg/L. Practices in the home may raise the levels of these components and may also introduce harmful chemicals and indigestible solids into the system. Although the AdvanTex system is robust enough to accommodate a houseful of weekend guests or a couple of days of canning, residents must be aware that in the long run, certain habits can harm their septic system or increase the need for system servicing and/or pumping. The Troubleshooting section of this manual lists some household practices to inquire about when a system has problems.

In addition to the composition of a home's effluent, the **size of the tank** and the **volume of the effluent** also affect performance. Residential systems are sized and designed to accommodate the North American average of 50-60 gallons per person per day and are sized for a certain number of residents. A change in the number of residents, or a sudden increase in their water use per capita, can push wastewater through the tank without allowing the minimum 24 hours of retention time required for thorough separation and digestion of wastes.

Finally, the tank and all pipe joints must be **watertight** to prevent both infiltration and exfiltration of liquid. Infiltration of rainwater or groundwater will overload the system, preventing proper stratification in the processing tank and overloading the AdvanTex textile filter. Exfiltration of liquid effluent from the tank can make liquid levels too low for stratification, leading to clogging of the Biotube® effluent filter. Of course, exfiltration also pollutes the soil, and potentially the groundwater.

AdvanTex Textile Filter

The AdvanTex textile filter provides secondary wastewater treatment. The filter is a sturdy, watertight fiberglass basin filled with a nonwoven textile material. This lightweight, highly absorbent media treats a large amount of wastewater in a small space because it has a very large surface area — about five times greater than that of an equivalent volume of sand, for example. Textile also has a greater void volume (for free flow of oxygen) and greater water-holding capacity.

These properties make it an excellent environment for aerobic micro-organisms to live and digest the nutrients in effluent. As effluent from the processing tank percolates through and between the sheets of textile, the microorganisms remove what they need from it, reducing BOD_5 and TSS. Also, the aerobic conditions within the AdvanTex filter are ideal for microbes that convert ammonia to nitrates (nitrification). For sites where maximum denitrification is necessary, AdvanTex filters can be configured in Mode 3, so that the filtrate recirculates back to the high-carbon, low-oxygen environment at the inlet end of the processing tank, which is ideal for microbes that reduce nitrates to nitrogen gas (denitrification). Harmless nitrogen gas is then released back into the atmosphere.

In addition to being affected by **oxygen**, the AdvanTex filter's performance is affected by **mass loading, hydraulic loading, strength,** and **chemical characteristics** of the influent. If the effluent coming from the processing tank is contaminated with harsh chemicals or excessive grease, the biomat of microorganisms will suffer. The graphs on the next page show that low-to-moderate loading rates produce BOD_5 and TSS of <5 mg/L, and higher loading rates produce BOD_5 and TSS in the range of 15-25 mg/L.

About Recirculation Ratio

Maintaining an **appropriate recirculation ratio** is important for proper functioning of the system. Adjusting the frequency and length of the doses of effluent delivered from the tank to the AdvanTex filter optimizes the conditions for the microorganisms.

A recirc ratio that's too high can generate a highly aerobic biomat growth on the pump filter. It also increases alkalinity consumption and dissolved oxygen concentration in the processing tank, which can inhibit denitrification. Conversely, a recirc ratio that's too low can tend to liberate periodic odors during dosing events. The optimum ratio is typically between 2:1 and 6:1.

Normal Performance of the AdvanTex System

The table below summarizes the typical levels of BOD_5, TSS, and TKN in each part of the AdvanTex system, if proper conditions (described in the preceding section) are met:

Typical Values in the AdvanTex Treatment System

	BOD_5 (mg/L)	TSS (mg/L)	TKN (mg/L)
Raw Influent[1]	450	500	70
Primary Chamber Effluent	150	40	70
Secondary Chamber Effluent[2]	15-40	10-20	[4]
AXN Filtrate[3]	5	5	[4]

[1] Source: Crites and Tchobanoglous. *Small and Decentralized Wastewater Management Systems,* p. 180, 183, 1998. McGraw-Hill. Based on 50 gpcd.

[2] Will vary with recirc ratios and mode configuration. The numbers here represent a recirc ratio between 2:1 and 6:1 and are derived from Orenco and third-party testing in Mode 1.

[3] Actual performance results, based on a six-month accumulative average from NSF (National Sanitation Foundation) testing on the AX20N at 500 gpd, using composite sampling. Performance and servicing frequencies will vary relative to the mass load being treated. Procedures for treating excessively high loads will require engineering review. For more information, please review AdvanTex Design Criteria.

[4] Dependent on treatment system configuration and recirc ratios.

When all parts of the AdvanTex system are operating correctly and the component values in each part are within the limits above, the typical values or properties from field tests of AdvanTex effluent (filtrate) are summarized in the table below.

Typical Values for AdvanTex Effluent (Filtrate)

Parameter	Sampling Method	Typical Values or Properties
Clarity	Visual[1]	Clear (≤15 NTUs)
Odor	Sniff[2]	Non-offensive (musty is OK; rotten egg or cabbage is not OK)
Biotube® filter	Visual	No liquid level differential inside/outside vault, one-year cleaning interval
Oily film	Visual; inside the pump vault	None; no red, blue, green, or orange sheen
Foam	Visual; inside tank	None
pH	Field[3]	6-9
DO	Field[3]	≈2.5-6

If effluent is cloudy or smells pungent or if the biomat on the textile filter appears greasy, waxy, or oily, laboratory tests of the filtrate will aid troubleshooting. Following are the typical values for various lab tests of AdvanTex filtrate.

[1] To check for clarity, service providers can carry a portable turbidity meter or calibrated turbidity standards.

[2] To check for odor, service providers can simply sniff the effluent sample or can use a sulfide measuring packet or an olfactory snifter device.

[3] To check for pH, service providers can use litmus paper, a pocket pH meter, or a benchtop pH meter.

Typical Values for Supplemental Lab Tests

Sampling Parameter	Sampling Method	Typical values[1] (mg/L)	
		Mode 1	Mode 3
BOD_5	Grab	≈10	≈10
TSS	Grab	≈10	≈10
TN	Grab	≈25	≈10-20[2]
G&O	Grab	<1	<1

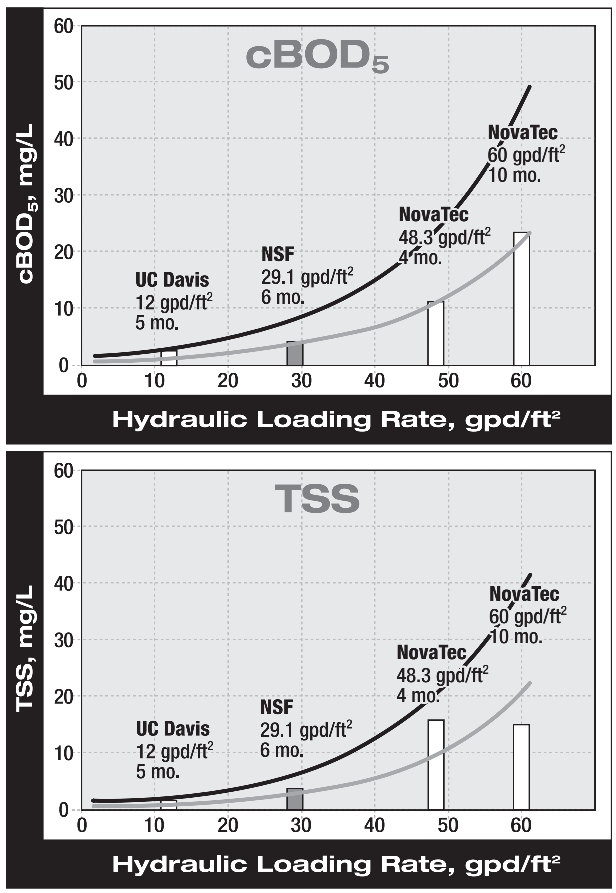
[1] Values are based on testing by Orenco and third parties.

[2] Typical nitrogen reduction ranges from ≈60-70%, with sufficient carbon source and alkalinity.

[3] To check for dissolved oxygen, use a DO meter or DO test kit.

Effluent Quality vs. Hydraulic Loading Rates

ANSI/NSF Standard 40 and Other Third Party Testing Results



95% Confidence Level — Current Average

Recommended Design Range for Residential Strength Waste

Troubleshooting Effluent Quality

Once you know the typical values for wastewater treatment system performance, you can be proactive and troubleshoot nontypical process indicators, before system performance is affected.

Low Effluent Quality

If your effluent samples are cloudy and color/turbidity is significantly higher than expected (greater than 15 NTU), do the following:

- Check the Biotube® filter for clogging.
- Check to see if the textile filter smells of chemicals (medication, chlorine, etc.) or has a granular or crusty appearance. (For example, a white crystalline crust could signal that water softener discharge or industrial strength detergents have been flushed into the system.)
- Check to see if the recirc ratio is too high or the pump dose time is too long. If the effluent $cBOD_5$ is high and TSS is low, a large amount of soluble $cBOD_5$ has not yet been consumed. That would likely be because the recirc ratio is too low for the influent strength or insufficient start-up time has elapsed. Typical organic reduction within the first 24 hours in residential systems is about 75% or greater. As the biomat begins to develop, greater reductions in the soluble $cBOD_5$ will occur (typically within the first 7-10 days). With a higher influent strength, the soluble $cBOD_5$ would not be readily removed until the biomat on the media is established.
- Check that ventilation is occurring, at the pod and from the house to the tank.
- Interview the users about system abuse, especially in the area of harmful chemicals, solvents, strong cleaning agents, or water softener backwash.

Special Note about Water Softeners: *Water softener backwash is extremely high in salts, which can disrupt system performance, especially nitrogen reduction processes. Talk with residents to make sure that no water softener backwash is discharging into the processing tank. Plumbing water softener backwash into the processing tank voids the warranty.*

If none of these troubleshooting steps makes a difference, lab tests may be necessary to determine the cause of the problem. Call Orenco for recommended lab tests or design remedies.

Odor

If the tank or textile filter smells like rotten eggs or cabbage:

- Check dissolved oxygen levels using a DO meter or DO wet test kit.
- Note filtrate DO levels that are <2.5 (less than 2.5) or >6 (greater than 6) mg/L.

Filtrate DO that's <2.5 mg/L indicates insufficient oxygen. If the filtrate DO is <2.5 mg/L:

- Check filter surface for evidence of clogging.
- Check that the pump is working.
- Check that ventilation is occurring, at the pod and from the house to the tank.
- Check that the recirc ratio isn't too low; increase if too low.
- Check that influent strength isn't too high (see AdvanTex Design Criteria).
- Check to ensure hydraulic retention time isn't too high.

Filtrate DO that's >6 mg/L indicates excessive aeration. If the filtrate DO is >6 mg/L:

- Check to ensure recirc ratio isn't too high.
- Check to see if influent flows are below normal.
- If influent flows are below normal or recirc ratio is too high, reduce recirc ratio.

Troubleshooting Other Symptoms

Biotube® Filter Clogging

If a visual inspection of the Biotube® filter for biomass build-up shows the need for cleaning more often than once a year (annual cleaning is typical for recirculating systems), try the following:

- Verify the pump isn't running too long (typically 3 cycles/hour).
- Ensure the recirc ratio isn't too high.
- Verify normal DO levels; if high, reduce recirc ratio.
- Check for below normal influent flows.
- Check influent Grease & Oil and TSS; if excessive, a review of component sizes may be required.

Oily Film

All signs of oil or grease anywhere in the system (in the tank, in the vault, on the effluent filter or textile filter) must be investigated. Ask the system user to identify the probable source:

- Recent change of car oil?
- Canning meat or poultry?
- Excessive use of garbage disposal?
- Excessive use of bath or mineral oils? (Jacuzzi® tub?)
- Excessive use of detergents?

If the system user can't identify the probable source, try the following:

- Sample and test at all process steps, including influent (if possible).
- Label, date, and photograph all samples.
  — When photographing, use standard glass beakers and set samples in front of a common, uniform background
- Check biomat accumulation at AdvanTex Filter.
- Note if biomat is yellowish and wax-like or lard-like. If so, scrape biomat sample for analysis:
  — Photograph/document biomat sample.
  — Send to lab with effluent samples.

Excessive grease and oil (>25 mg/L) is typically a design and management concern with commercial applications.

Foam

Foam rarely occurs in packed bed filters. If you see foam in the textile filter, call Orenco.

Troubleshooting Nitrogen Reduction

AdvanTex Treatment Systems do an excellent job of reducing nitrogen, especially in the Mode 3 configuration, where total nitrogen (TN)* is typically reduced to 10-15 mg/L, from typical influent total Kjeldahl nitrogen (TKN)** of 70 mg/L. Because many people purchase AdvanTex for its nitrogen-reducing capabilities, and because nitrogen reduction is a complex, many-staged process, it's important to understand the process, its related factors, the signs of effective nitrogen reduction, and how to keep the process optimized.

It's also important to know the TN limits required by the system user's permit. Some regulatory agencies have no requirement; some require a specific percentage reduction of a certain kind of nitrogen (90-95% nitrification of ammonia nitrogen, for example); and some require that TN be reduced to levels at or near drinking water quality at the point of final dispersal. A level of 20 mg/L TN is becoming increasingly accepted by regulators because it's typically achievable without relying on supplemental carbon and alkalinity feeds.

Finally, because influent characteristics greatly affect the amount of nitrogen reduction possible from any given system, it's vital to know the alkalinity of your waste source and the local or regional norms for organic and ammonia nitrogen.

* Total Nitrogen (TN) is the sum of organic nitrogen (ON), ammonia nitrogen (NH_3-N), nitrate nitrogen (NO_3-N), and nitrite nitrogen (NO_2-N).

** Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen (ON) and ammonia nitrogen (NH_3-N).

The Process

Appendix 1 describes the nitrification/denitrification cycle in more detail, but a brief description should help you with most troubleshooting. In nitrogen reduction, ammonia is converted to nitrate in an aerobic environment, and then reduced through bacterial action in an anaerobic environment to nitrogen gas, which is released harmlessly to the atmosphere. Optimum nitrogen reduction typically requires the following:

- Adequate alkalinity of approximately 250 mg/L or higher (a lab test shows levels).
- pH of 6-9. Fixed-film microbial processes generally thrive between pH 6 and 9. Treatment problems typically result from rapid changes in pH rather than extreme long-term mean values, although long-term levels can result in less efficient process activity.
- Filtrate DO level of 2.5-6 mg/L, process tank DO level of <1 mg/L.
- Adequate time for the nitrifying bacteria to develop (one to three months).
- Adequate temperature (below 40° F retards the process).
- Good organic removal.

For a thorough description of the nitrogen reduction process, see Appendix 1. In residential wastewater, the ammonia level is typically about 60 mg/L and the TN is typically ≈70 mg/L.

Signs of Effective Nitrogen Reduction

Service providers frequently ask us, "How do I know if my wastewater treatment system is reducing nitrogen?" A thorough description of key indicators is included in Appendix 1. Following is a brief summary:

- Clear, odorless filtrate effluent (a "see and sniff" test is generally considered sufficient).
- Normal-looking biomat on the textile filter (light-brown to dark-brown and gelatinous in texture).

Additional filtrate tests will show ...

- Typically, low BOD_5, low turbidity and high clarity.
- DO of ≈ 2.5-6 mg/L.
- Low ammonia levels (≈<1-3) and relatively high nitrate levels, since nitrification converts ammonia to nitrate.

Troubleshooting Nitrogen Reduction (continued)

Troubleshooting Nitrogen Reduction

If you suspect that the system is not meeting expectations for nitrogen reduction, troubleshoot each of the critical factors that contribute to optimum nitrogen reduction, to determine a cause.

Filtrate Alkalinity Too Low — Sufficient alkalinity is required to achieve the desired degree of nitrification for any wastewater treatment system, because it takes 7.14 parts alkalinity to nitrify 1 part ammonia.

If filtrate alkalinity is too low:

- Check the recirc ratio; a high recirc ratio increases alkalinity consumption.
- Check influent TKN or ammonia levels and source alkalinity.

If a large quantity of nitrification is required, it may be necessary to add alkalinity-raising chemicals to the system.

Filtrate pH Too Low — Nitrification is particularly sensitive to pH but tends to thrive at levels between pH 7 and 8. The nitrification process releases hydrogen that consumes alkalinity and causes pH levels to drop. A pH level of <6 retards microbial activity of all kinds, including denitrification, and with a pH level <5.5, nitrification may show signs of degradation. Maintaining an alkalinity of 50 to 80 mg/L in the effluent is typically sufficient to maintain pH levels above 5.5. If the filtrate pH level is too low:

- Check influent alkalinity level (pH drops when too much available alkalinity is consumed).
- Check recirc ratios; reduce if too high.
- Ask system user about chemical discharges into the system, including carpet cleaners, chlorine, and photo developing agents.

Filtrate DO Levels Outside Range of 2.5-6 mg/L — If filtrate DO is too low (indicating insufficient oxygen), the system may release sulfide odors during dosing events, or there may be a more lasting smell within the filter pod. Try the following:

- Check for surface clogging/ponding and clean as necessary.
- Check air flow through the vent assembly.
- Check the recirc ratio; if it's too low (<2:1), increase as necessary.

If your filtrate DO is too high (indicating excessive aeration), it's likely that excessive recirculation or insufficient hydraulic retention time are factors. Try decreasing the recirc ratio.

High Filtrate Ammonia Levels — Because ammonia is biochemically oxidized to nitrate during nitrification, high ammonia levels are a sign that something is amiss. Try the following:

- Check for surface clogging/ponding and clean as necessary.
- Check for sufficient aeration (measure DO).
- Ensure no blockage of air flow into textile filter (indicated by thick biomat development or a build-up of grease and oils).
- Ensure no blockage in the manifold, causing ...
  - — Localized hydraulic overloading, saturation
  - — Short circuiting
- Check for sufficient alkalinity; if insufficient, consider supplemental buffering using equipment that automatically adds an alkaline compound to the system. Call Orenco Engineering for assistance, if necessary.

Troubleshooting Nitrogen Reduction (continued)

Low Filtrate Nitrate Levels — Residential packed bed filters normally yield more than 98% nitrification (conversion of ammonia to nitrate). Therefore, the ammonia levels in the filtrate should be low and the nitrate levels higher. Some denitrification occurs in the packed bed filter, so the normal nitrate level may vary. Be sure you are familiar with the mode of operation, as some AdvanTex modes are configured to produce lower nitrate levels. If it appears that nitrification is dropping off:

- Check the recirc ratio; adjust as necessary (high recirc ratios may drive pH too low for effective nitrification/denitrification, and low recirc ratios may not provide sufficient aeration).
- Verify incoming ammonia levels.
- Check recirc/blend for excessive organic food source (high BOD_5 may cause greater oxygen demand through the filter, reducing nitrification).

Adequate Time and Temperature — Nitrifying bacteria require one to two months to develop, and extremely cold temperatures (below 40° F) retard that process. If the AdvanTex Treatment System has been installed in a very cold climate, nitrification may not "kick in" for several months until warmer temperatures are reached. Typically, a June-September installation provides the necessary temperatures for a 30-60 day nitrification start-up time. Once nitrifiers colonize, they typically continue to nitrify through normal winter conditions. Only in severely cold regions should additional insulation be necessary.

Appendix 1: More Information about Nitrogen Reduction

Nitrogen removal (or "nitrification/denitrification") is a biochemical process. In nitrification, ammonia is oxidized to nitrate ($2NH_3$ converts to $2NO_3$ + $3H_2O$). This nitrate is then reduced through bacterial action (denitrification) to nitrogen gas, which is released harmlessly to the atmosphere.

During the nitrification process, about 9 parts oxygen are consumed in converting 2 parts ammonia to nitrate. Therefore, depending on the concentration of ammonia, a considerable amount of air may be needed. Other processes, like BOD_5 reduction, may occur simultaneously and further elevate the demand for aeration, especially if the organic level is high. In an abundance of air, all the aerobic or facultative microbes compete for their share of oxygen.

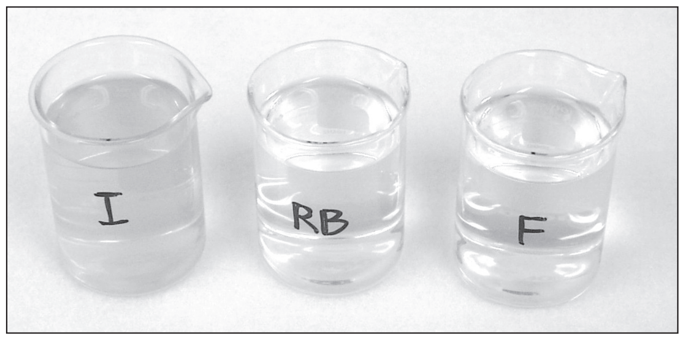
When the organic concentration is high, the microbes that oxidize organic matter, primarily the heterotrophic bacteria, are aggressive and tend to outcompete other microbes for the available free oxygen in solution. Ammonia is oxidized by autotrophic bacteria, which do not have as aggressive a growth rate, so if oxygen is not abundant, nitrification suffers. Consequently, the nitrification process usually lags until the organic concentration is depleted or until sufficient oxygen is present. At a 2.5:1 BOD_5/TKN ratio, the nitrifiers may only make up about 10 percent of the microbial population. At 0.5:1 BOD_5/TKN, the nitrifiers make up about 35 percent of the population.

In a filtering process, the filter column must be deep enough, or the filter media must be efficient enough at filtering organic particles, to deplete organic concentrations to a level in which a sufficient population of nitrifiers will be sustained. The physical (dimensional) features of the filter will vary depending on the media's characteristics — void ratio, moisture holding capacity, and effective surface area per unit volume ratio. Tankage, surge capacity, application rates, and loading characteristics are other design considerations that play a role in the sizing of the filter unit.

Performance Indicators

To judge the nitrogen-reducing performance (or potential) of any wastewater treatment system, be sure to check the following performance indicators:

Clear, Odorless Effluent — Simple, "see and sniff" tests can be performed easily in the field. Effluent from packed bed filters (recirculating textile filters, recirculating sand filters, intermittent sand filters) that are performing well should be clear (with turbidity <20 NTUs) and odorless.



Tests for Ammonia and Nitrate Nitrogen — If the system is oxidizing ammonia to nitrate (nitrifying), lab tests should measure relatively low ammonia levels and relatively high nitrate levels in the filtrate. Because nitrification responds to many and varying conditions within the aerobic treatment processes, *ammonia and nitrate nitrogen levels in the filtrate are the most ideal constituents to watch for any changes in performance.* Start-up times can be plotted, optimum recirc ratios can be gauged, cleaning frequencies can be predicted, and nonvisible clogging or saturation can be detected by watching either of these constituents.

Typical nitrification in single-family residential systems is expected to be in the 98-99% range. Investigate if the process appears to degrade by 5 percentage points or more.

BOD_5 — The nitrification process requires oxygen, which is why nitrification is enhanced when BOD_5 is extremely low. Measures of filtrate BOD_5 should be <15 mg/L, although higher BOD_5 may not necessarily correlate with low levels of nitrification.

Typical influent characteristics are shown on page 8. When BOD_5 is high, there is a greater organic demand for oxygen, which may hamper the nitrogenous demand for oxygen. Increasing the recirc ratio should help establish oxygen balance.

Appendix 1: More Information about Nitrogen Reduction (continued)

Biological Growth on Filter — With "fixed film" treatment systems, biological growth on the filter media is natural. The biomat should appear light-brown to dark-brown in color and gelatinous in texture.

Dissolved Oxygen — Dissolved oxygen also provides critical information with which to diagnose how well a system is performing. Measures of DO should be in the range of 2.5 to 6 mg/L. If the DO level drops, the degree of nitrification will normally drop as well, which could be a sign of blinding or saturated flow conditions — anything that might inhibit free air from flowing into the system. (Nevertheless, it's quite possible to have low filtrate DOs and still have high effluent quality, as measured by BOD_5 and TSS levels.)

pH — For normal residential nitrogen loads, pH is typically maintained between 6 and 8.

Influent Characteristics — Influent characteristics (see page 9) will greatly affect the amount of nitrogen reduction that is possible from any wastewater treatment system. High solids and/or fats and cooking oils increase the oxygen demand and accumulation of material on and within the media, affecting the available oxygen for nitrification.

Alkalinity — The nitrification process releases hydrogen ions into solution, which tends to lower the pH level. Alkalinity is essential for nitrification. For each part ammonia that is nitrified, 7.14 parts alkalinity are consumed (buffering the acidity caused by the release of hydrogen ions). Consequently, if the degree of nitrification is less than expected, it could simply be a lack of sufficient alkalinity to support more. Typical residential nitrification requires alkalinity above about 250 mg/L for recirculating processes and double that for single-pass processes.

Many wastewater streams do not have sufficient alkalinity to support complete nitrification. In this case, nitrification may deplete the alkalinity, and pH may drop to a level that retards the microbial activity (<6). Recirculating the effluent helps, since half the alkalinity can be restored in the recirc or process tank, wherever denitrification occurs (and adjusting the recirc ratios may also bring the pH back to preferred operating levels). But wastewater streams that are alkalinity-starved can't provide for 100% nitrification.

The use of low flush fixtures can reduce nitrification performance. Low flush fixtures tend to reduce hydraulic loads, which causes elevation of wastewater constituents (i.e., higher concentrations of BOD_5, TSS, TKN, etc.). In this case, the available alkalinity in the water supply may not be adequate to accomplish the full level of nitrification desired.

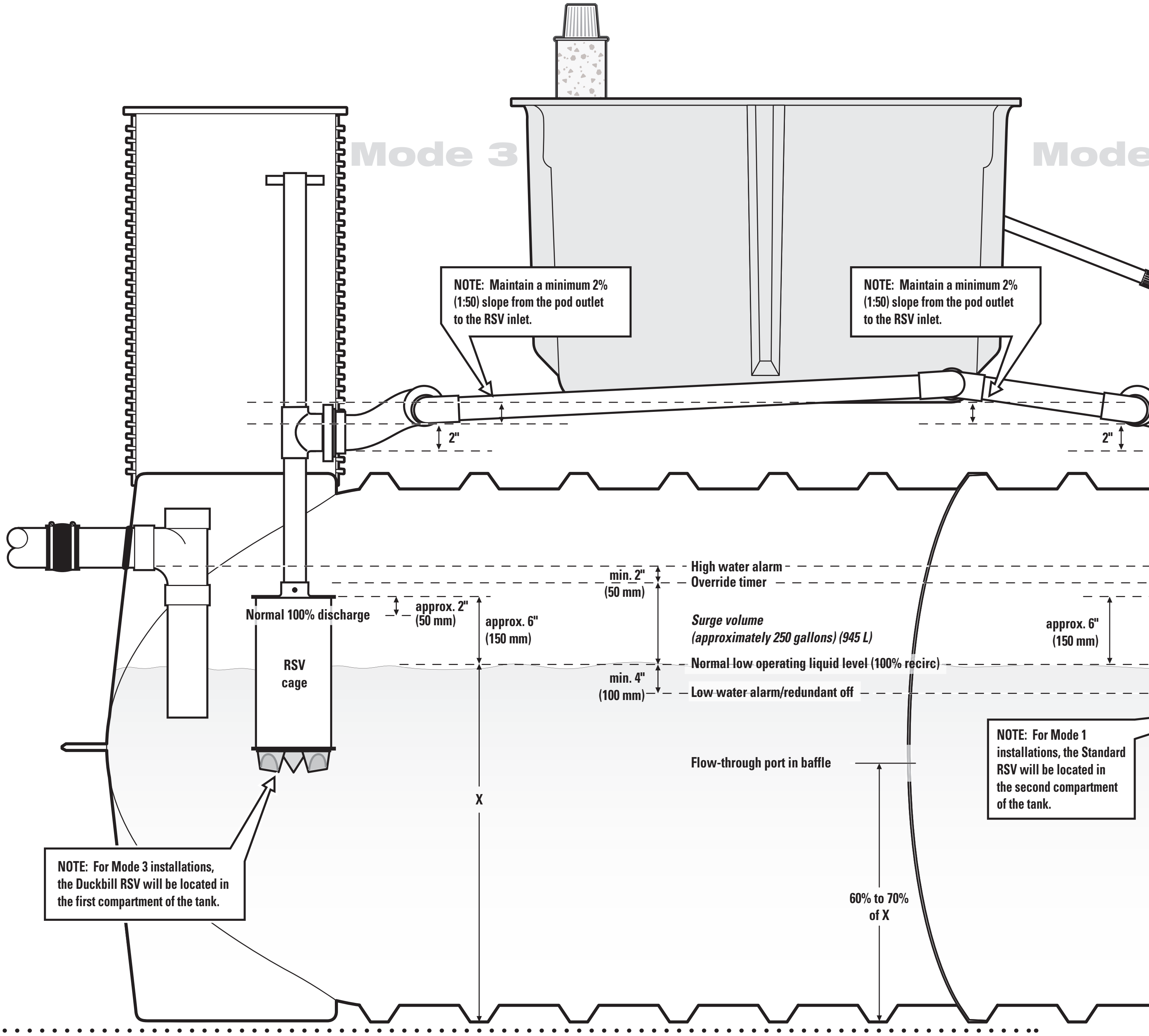
These constraints exist for all wastewater treatment operations, regardless of whether the operation involves a suspended growth contact stabilization process or an attached growth packed bed filter. Packed bed systems will perform better, especially if they have a large attached growth surface area per unit volume ratio, because the micro-sites near the attached side of the biomat, where denitrification typically occurs, return some of the alkalinity. Textile packed bed filters, because of their large surface area per unit volume ratio, tend to perform even better.

Nevertheless, additional buffering may be necessary to accomplish the level of nitrification desired. In low alkalinity conditions, pH adjustment can be made with the addition of quicklime or hydrated lime, soda ash, or caustic. If the alkali is to be introduced at a process point preceding sedimentation zones, such as in the tank, lime would be preferred. Soda ash and caustic both contain sodium, which is a dispersant and will impede settling of solids in the tank.

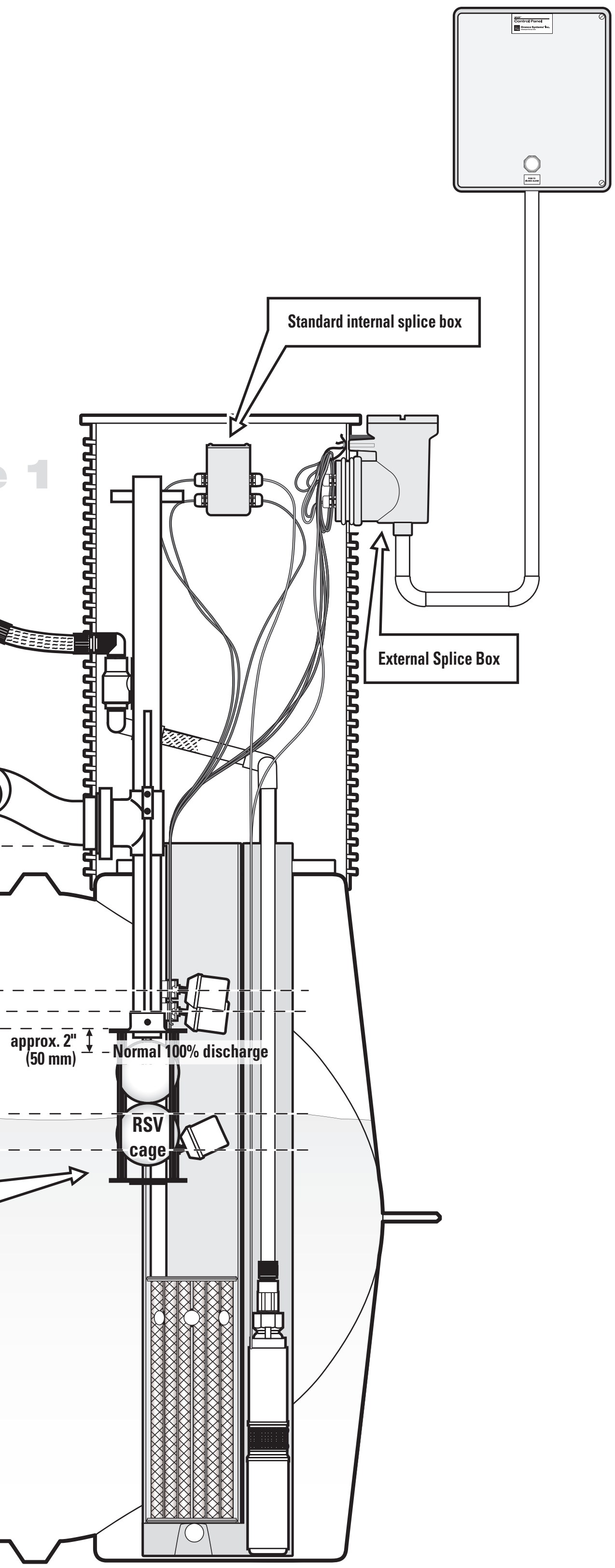
Appendix 2: Float and RSV Settings

Orenco will provide the float and RSV settings for tanks that are approved for use with AdvanTex Treatment Systems in your area. Service Providers are simply required to verify that the float and RSV settings are correct.

This diagram shows how these settings are established for AdvanTex Treatment Systems that use a VeriComm® Control Panel. The diagram shows both a Mode 1 and a Mode 3 setup. For Mode 1 setups, the recirculating splitter valve (RSV) is installed in the second compartment, with the Biotube pump vault. For Mode 3 setups, the RSV is installed in the first compartment, under the inlet riser.



Appendix 2: Float and RSV Settings (continued)



Typical RSV Levels

For stinger pipe lengths up to 24 in. (610 mm) long, the "normal low operating liquid level" will be approximately 5-6 in. (127-152 mm) below the top of the RSV cage. (The normal low operating liquid level is the level at which 100% of the filtrate returns to the tank.) For most residential applications, the recommended surge volume — the volume between the low liquid level and the high water alarm float — is approximately 250 gallons (948 L). For Mode 3 installations, the duckbill model RSV, which has a flexible PVC tube that vents the RSV cage to atmosphere, is required.

Typical Float Levels

Be sure to check the plans for any site-specific or tank-specific float settings. The top float is normally set equal with the tank's invert of inlet. The bottom float should be approximately 4 in. below the normal low operating level.

NOTE: *Before leaving the site, verify that the "low water alarm/redundant off" float is positioned at least 10 in. (254 mm) below the top of the RSV cage.*

Appendix 3: Timer Settings

The following chart shows recommended timer settings for a new system.

RESIDENTS	TIME ON (SEC)	TIME OFF (MIN)	NOTES
2	10 sec (0.17 min)	20.00	• Assumes water usage of 50 gal. (190 L) per person per day and a return recirculation ratio of 3 : 1 (Filter recirculation ratio of 4 : 1). • Override OFF cycle time is set at one-half of the OFF cycle time. Override ON cycle time is set the same as the ON cycle time.
3	15 sec (0.25 min)	19.75	
4	20 sec (0.33 min)	19.45	
5	25 sec (0.42 min)	19.70	
6	30 sec (0.50 min)	19.50	

As you gain experience with a system, you may conclude that you need to make adjustments, sometimes significant ones. This worksheet is intended to help you determine appropriate start-up timer settings (Pump ON, Pump OFF) for a single-pod AX20 system. Typical values and ranges are provided for each parameter. If you have any questions or if your values fall outside the desired ranges on this worksheet, contact your Dealer.

PARAMETER		TYPICAL VALUES	NOTES
	Number of people	3	Range of 2 to 8 people.
	Water usage per person	50 gpd (190 L/d)	Typical daily average is 50 gal. (190 L) per person.
Q_i	Actual daily flow (total)	150 gpd (570 L/d)	(Number of people) x (water usage per person).
R_b R_f	Return recirculation ratio Filter recirculation ratio	3 : 1 4 : 1	You can adjust this ratio (return flow to forward flow) up or down depending on system performance. (Range of 2 to 6.)
	Total daily flow to AX20	600 gpd (2280 L/d)	(Actual daily flow) x (return recirculation ratio + 1). Must be ≤ 3000 gpd (11,370 L/d). Actual flow should not exceed 500 gpd (1895 L/d). (500 gpd x 6:1 R_b = 3000 gpd)
Q_d	Actual pump dose rate	33.3 gpm (126 L/min)	Determine this value by field-testing or by using Orenco's PumpSelect™. Start at the low end.
T_d	Pump ON cycle time (dose)	0.25 min	Select a value between 0.17 minutes (10 seconds) and 0.75 minutes (45 seconds).
T_r	Pump OFF cycle time (rest)	19.75 min	See Pump OFF equation below.

PUMP OFF EQUATION **EXAMPLE**

Plugging in the above values and rounding results in the following:

$$T_r = \left[\frac{1440 * T_d * Q_d}{(R_b + 1) * Q_i} \right] - T_d$$

$$T_r = \left[\frac{1440 * 0.25 * 33.3}{(3 + 1) * 150} \right] - 0.25 = 19.74 \approx 19.75$$

After you determine your Pump ON and Pump OFF times, double check to make sure your start-up settings fall within the cycle time (CT) range, below. If they don't, make adjustments per the "Note."

ADDITIONAL PARAMETERS		TYPICAL VALUES	NOTES
CT	Cycle time	20 min	Low flow applications may result in cycle times of an hour or more, which can cause the media to dry out or odors to develop in the recirc tank. If CT is much more than 30 minutes, consult your Dealer or Orenco for suggested adjustments.
	Pump cycles per day	72 cycles	1440 min/day ÷ (OFF cycle time + ON cycle time). Must not exceed the pump's maximum rated cycles of 300 cycles per day.
	Gallons per cycle	8.3 gal. (31 L)	With 68 orifices and using the T_d range recommended above, you will maintain the recommended 0.08 to 0.25 gal. (0.45 to 0.95 L) per orifice per dose.

Appendix 4: Glossary

Alkalinity: The amount of ions available in the filtrate to react with hydrogen ions. Although pH paper or a pH meter provides a quick field measure of the overall balance of acidity vs. alkalinity in the system and is useful for detecting changes that may cause problems, quantitative determination of alkalinity (measured in mg/L) is done in a lab.

BOD: Biological Oxygen Demand, a measure of the amount of organic material in wastewater. cBOD means carbonaceous BOD; the terms are often casually used interchangeably. $cBOD_5$ means "five-day cBOD" and is a lab test in which the sample is incubated for five days.

DO: Dissolved oxygen, in mg/L. It can be measured in the field using a DO meter or colorimetric kit, or in a lab.

G&O: Grease and oil, in mg/L, measured in a lab.

NTU: Clarity and color of wastewater can be measured in nephelometric units (NTU). Clarity of a sample in a glass container can be compared by eye against a prepared sample. To obtain a quantitative measure of turbidity, a turbidity meter can be used in the field or in a lab.

pH: A measure of the acidity or alkalinity of wastewater on a scale from 0 (acid) to 14 (alkaline), with 7 being neutral. pH can be measured in the field using pH test strips or a pH meter.

TN, TKN: Total Nitrogen (TN) is the sum of organic nitrogen (ON), ammonia nitrogen (NH_3-N), nitrate nitrogen (NO_3-N), and nitrite nitrogen (NO_2-N). Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen (ON) and ammonia nitrogen (NH_3-N).

TSS: Total suspended solids, in mg/L, measured in a lab.

Notes

O&M MANUAL

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AdvanTex Treatment System AXN Models meet the requirements of ANSI-NSF Standard 40 for Class I Systems.

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