The Hungerford & Terry Nitrate Removal System:

A high capacity, efficient method for removal of nitrate from water.

12,000 GPM Countercurrent Regenerated system operating in Illinois

Nitrate – An unwelcome Addition to your water

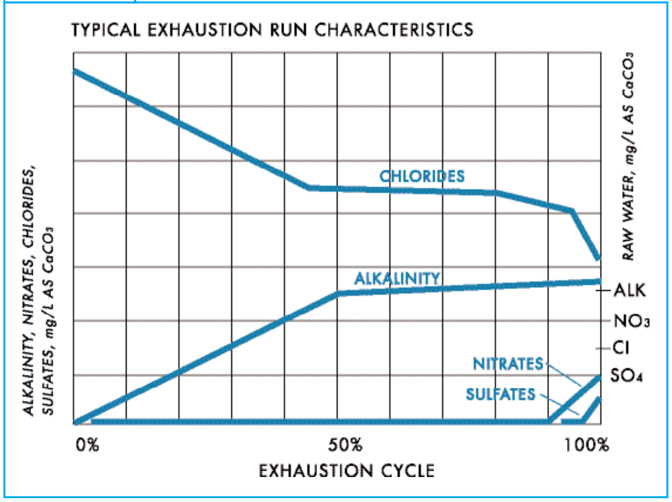
One of the compounds of most concern in water in recent years is nitrate. The contamination of groundwater and, in some instances, surface water, by nitrates can be caused by fertilizer run-off in agricultural areas, septic tank field percolation and land disposal of wastes. In high concentrations, nitrates pose severe health risks to people, especially infants, and livestock.

Nitrate Removal Process

Federal Primary Drinking Water Standards, established by the Environmental Protection Agency, restrict the itrate level in water to 10 mg/L. H & T's countercurrent nitrate removal system easily reduces nitrates to a level much lower than that permitted by Federal standards.

Our system reduces the nitrate level in water through a chloride cycle anion exchange. The nitrates, alkalinity and sulfates are exchanged for chlorides on strongly basic anion exchange resin (see chart #1). The exchange capacity is largely governed by the concentrations of nitrates and sulfates, which are effectively retained until breakthrough. Alkalinity and chlorides have little effect. Initially, the bicarbonate alkalinity is removed by the anion resin but is re-exchanged (released) later in the exhaustion cycle.

chart #1



During the service run the chemical reaction is:

$RCl + NaNO_3 = RNO_3 + NaCl$

During regeneration the reaction is:

$RNO_3 + NaCl = RCl + NaNO_3$

where R denotes the anion exchange resin

System Design

The Hungerford & Terry team of engineers has designed and tested two types of systems to meet your nitrate removal needs. We recommend the countercurrent removal system for most facilities because it is the most efficient in design and operation (see chart #3 on back cover). However, if your system is small and capital costs are of greater concern, the cocurrent system may be best for your operation.

Countercurrent Operation

Because the concentration of nitrates leaving the anion exchanger in the Hungerford & Terry system is much lower than 10 mg/L, a portion of untreated water can bypass the unit. This raw water, which contains high levels of nitrates, is then blended with the treatment system effluent to produce a final product with nitrate concentrations to any desired level below the 10 mg/L requirement.

The H & T system uses countercurrent regeneration to attain the lowest possible leakage from the exchanger, allowing a larger portion of water to bypass the treatment process. Our goal is to develop treatment plants that are smaller and more efficient than the conventional cocurrently regenerated systems.

Additionally, nitrate leakage from a countercurrently regenerated system is one-quarter to one-tenth the leakage from a cocurrently regenerated system. In the countercurrent system, the brine injection and slow rinse water are introduced at the bottom of the exchanger and flow upward through the compacted ion exchange resin bed (see chart #2). The resin at the bottom of the bed, which is the last resin the service water contacts, is the most fully regenerated. This results in the lowest possible nitrate leakage at nominal regeneration levels.

Countercurrent Regeneration

As the resin in the exchanger becomes exhausted, nitrates will begin to increase in the treated water. To insure efficient operation, the exchanger must be regenerated after every service run.

Step 1 – Backwashing
The resin is washed to remove suspended matter collected in the resin bed and to loosen and classify the resin bed. The wash process should continue until the waste water is relatively clear.

Step 2 – Brine Injection
Nitrates and sulfates are removed from the ion exchange resin by passing a pre-determined 6% to 8% brine solution through the resin bed. During this step dilute brine enters the bottom of the exchanger. The spent brine exits the exchanger at the regenerant collector located at the top of the resin bed.

Step 3 – Slow Rinse
The slow rinse step flushes out the bulk of the brine. This provides another 10 to 15 minutes of brine contact time with the resin, insuring thorough nitrate/sulfate removal.

Step 4 – Fast Rinse
The downflow fast rinse removes the last traces of nitrate and sulfate as well as any excess brine from the resin.

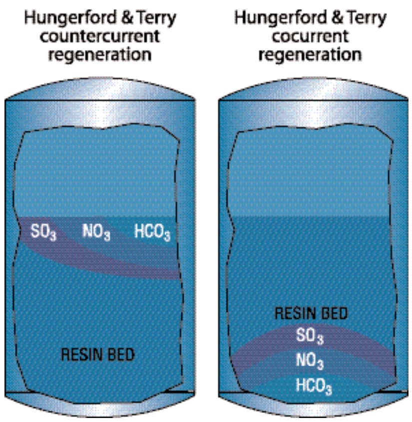
Cocurrent Operation

The cocurrently regenerated nitrate removal system utilizes the same principles of operation and chemistry as the countercurrent system. However, instead of the regenerant brine flowing up from the bottom of the bed to the top, the brine is introduced at the top of the bed and flows down through the bed in the same manner as the water during the service run.

Cocurrent Regeneration

Since the regeneration is also downflow, it is necessary to backwash a cocurrently regenerated system after every service run in order to remove suspended matter and relieve compaction. Following a downflow service run, the regeneration sequence would be: upflow backwash, downflow brine injection, downflow slow rinse and downflow fast rinse.

chart #2



Treated Water Characteristics

During the exhaustion cycle, nitrates, sulfates and alkalinity are exchanged for chlorides. The pH during the first part of the run is approximately 4.5 because the bicarbonate ion, with its buffering effect, has been removed from the treated water. There will be some nitrate leakage (usually less than 0.5 mg/L for countercurrent), depending on the concentration of nitrates in the raw water and the regeneration level. The sulfates will be essentially zero.

As the run progresses, the alkalinity will increase to its original level or higher. Nitrates and sulfates will continue to be removed. At the end of the cycle, nitrate leakage increases, followed shortly by an increase in sulfates. Throughout the run, the total concentration of anions does not change. Also, the cation concentration in the raw water remains the same.

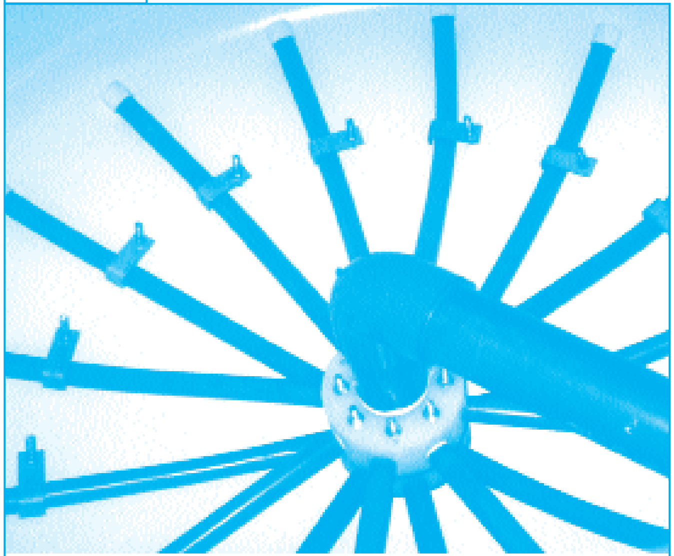
Equipment Design

Innovative, custom design equipment gives Hungerford & Terry a leading edge in the water purification business. The nitrate removal system is one example of how our company responds to the needs of our current and prospective customers by providing safe, reliable equipment.

A series of automated valves is used in the operation of the nitrate removal system. Valve actuation can be pneumatic, hydraulic or electric depending on the type of valve needed and our customer's preferences. H & T nitrate removal tanks are built of welded steel plate in accordance with Section VIII of the ASME Code. Non-code construction is also available where acceptable. Tanks are normally unlined with structural leg supports, a 12" x 16" manhole and prime painting. Tank linings, adjustable jack legs, larger manholes and special painting can also be provided as customer's needs dictate.

The underdrain of a typical countercurrent regenerated exchanger uses a hub-curved radial lateral design (see photo #1). It is constructed of schedule 80 PVC and consists of laterals curved to follow the contour of the exchanger bottom head. This eliminates the possibility of "brine hide-out" below the underdrain. The regenerant collector and inlet distributor are of the header lateral design and incorporate sufficient supports to resist all forces exerted on the distributors during service and regeneration steps.

photo #1



Hub - Curved Radial Lateral Underdrain Distributor

All automatic control panels used for automatic or semi-automatic operation of the nitrate removal systems, are designed, fabricated, wired and tested in our Clayton, New Jersey plant. Because we do not use subcontractors, we have complete control over design and quality.

The units, equipped with individual valves, can be designed for fully or semi-automatic operation. Additionally, many special types of control panels can be developed for either single or multiple unit installations.

Ordinarily, automatic controls use a contact meter head with an automatic reset counter which can easily be adjusted for a wide range of capacities. These controls can also be designed for installations requiring an alarm dial meter with adjustable, automatic reset registers.

Semi-automatic control panels require push-button initiation of the regeneration cycle. An alarm dial, alarm bell or warning light is used to signal the operator that the unit has reached the end of its nitrate removal capacity and requires regeneration. By pressing the start botton, the control circuit is energized to automatically operate the individual control valves.

Brine Tanks and Regeneration Systems

In general, nitrate removal units are equipped with one of the following brine tank and regeneration systems:

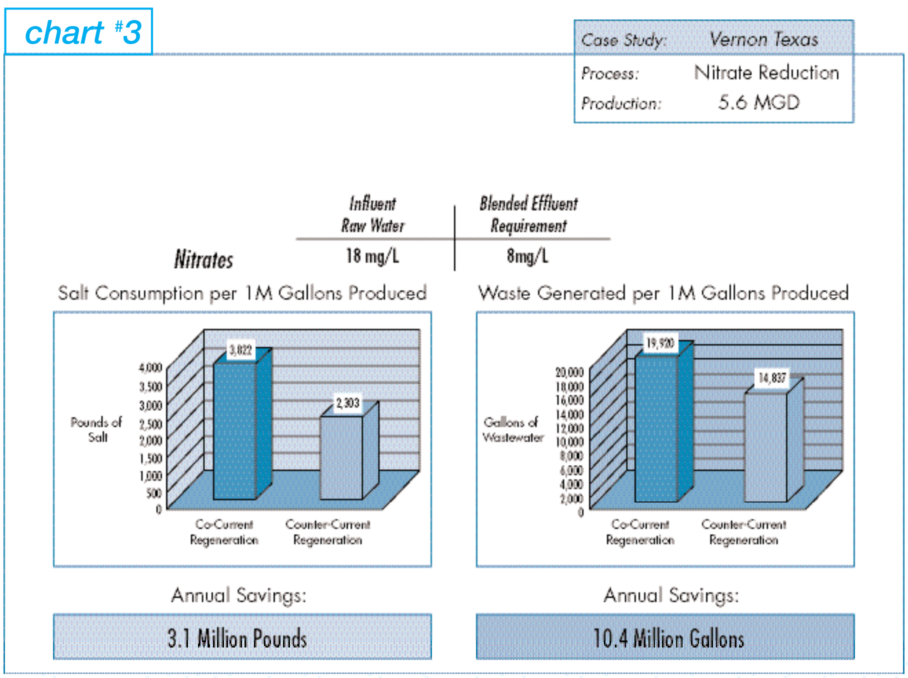
1. A single fiberglass combination saturator-measuring tank with gravel bed, collection system, brine transfer pump, and required valves and float gauge to indicate the correct amount of brine. Galvanized steel or unlined brine tanks are also available.

2. If large quantities of salt are consumed, a bulk salt saturator may be the best option. Saturated brine is pumped from the bulk saturator, sized to hold a truckload or carload of salt, directly to the exchanger units.

Alternative units can be developed to meet special requirements.

Accessories

Each exchanger is equipped with pressure gauges to indicate loss of head at various flow rates. Automatic backwash and brine rinse rate controls are used in an open sump or closed pressure drain system. Each system is also equipped with sampling cocks and a nitrate test kit.



References

- Borough of Clayton – Clayton, New Jersey
- Borough of Greencastle – Greencastle, Pennsylvania
- California Dept. of Corrections – Chino, California
- Campbell Soup Company – Napolean, Ohio
- City of Decatur – Decatur, Illinois
- City of Des Moines – Des Moines, Iowa
- City of Plover – Plover, Wisconsin
- City of Vernon – Vernon, Texas
- Consumers Illinois Water Co. – Danville, Illinois
- County of Suffolk Department of Health Services – Long Island, New York
- Town of Bridgewater – Brigdgewater, Massachusetts
- Village of Blissfield – Blissfield, Michigan
- Village of Whitting – Whitting, Wisconsin
- Vlasic Foods – Millsboro, Delaware
- Warwick Township – Lancaster County, Pennsylvania

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