



The Hungerford & Terry GreensandPlus™ Filter

A proven filtration system
for reliable, cost-effective removal
of iron, manganese and arsenic
from groundwater.



Hungerford & Terry, Inc.

Specializing in design, manufacture and service of custom-built water treatment systems... our only business since 1909.

For almost a century, H & T has designed and supplied various types of water treatment systems for municipal, industrial and power-plant applications.

Today, H & T, a privately held corporation, continues to specialize in filtration systems for iron and manganese removal, turbidity removal, and carbon adsorption. We are leaders in ion exchange technology, with capabilities for the design and manufacture of custom-built water treatment systems for softening, nitrate removal, demineralization, and both conventional deep bed and sodium cycle condensate polishing. We also offer both forced air and vacuum degasification.

In all, Hungerford & Terry is known for consistent excellence, competitive pricing, and the ability to provide continued services as required.

Development of the H & T GreensandPlus™ Filter

Prior to World War II, researchers in the water treatment field, working with well-known chemical theories of oxidation and reduction, developed the basic technology of manufacturing manganese greensand from the mineral glauconite. This medium found use in a small segment of the municipal and industrial water treatment market for the direct oxidation and removal of iron, manganese and hydrogen sulfide.

H & T perfected the manganese greensand process with the conception, design and introduction of the Ferrosand CR process, which was patented in 1965. In the 1990s, the Catalytic Oxidation* process was developed using a special Catalytic Grade Ferrosand media. This system operates at higher loading rates yet, does not require the use of potassium permanganate. From the beginning, our objective was to produce a top-quality filter system that would reliably remove iron and manganese.

More recently, H&T introduced our GreensandPlus filter system to remove iron and manganese.

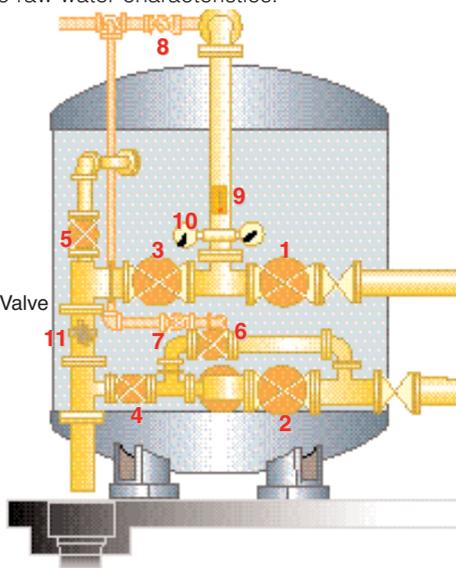
Hungerford & Terry has never attempted to turn out an off-the-shelf system that will "just meet" your water treatment requirements. Instead, we provide custom-designed-and-built systems, based on your specific design requirements, that are competitive in both capital and long-term operating costs.

GreensandPlus Filter Medium - The Core and Essential Component of the Ferrosand Filter

GreensandPlus is manufactured to exact specifications to ensure the complete oxidation of soluble iron, manganese and arsenic using stoichiometric quantities of oxidizing agents without the need for long reaction times or high pH levels. GreensandPlus is not one of the "magic media" with exaggerated claims of magnetic properties for the attraction of iron and manganese. As a filter medium, it operates on the chemical principle of oxidation and reduction and the well-known catalytic effect of manganese oxides. GreensandPlus has demonstrated its effectiveness as the proven technology in iron and manganese removal for many years.

A major benefit of GreensandPlus, attributable to its unique chemical properties, is that it can be used in two distinct methods of operation. This allows for flexibility in the design of the water-treating equipment with specific features tailored to the raw water characteristics.

1. Inlet Valve
2. Outlet/Backwash Valve
3. Backwash Outlet
4. Rinse Outlet
5. Draindown
6. Slow Refill (air/water wash)
7. Air Inlet
8. Air Pressure
9. Flow Indicator
10. Pressure Gauges
11. ΔP Switch



The external arrangement of a GreensandPlus air/water wash system.

*Request H&T Ferrosand Catalytic Oxidation Filter Bulletin.

The Hungerford & Terry CO and IR Filters: Two Methods of Design and Operation

GreensandPlus CO for Iron and Manganese Removal

The GreensandPlus catalytic regeneration (CO) process is used primarily when iron removal is the objective, with or without the presence of manganese. In use on thousands of installations, this method provides the most cost-effective design when iron predominates in the raw water.

The CO method utilizes a continuous pre-feed of any oxidant to the raw water prior to contacting the GreensandPlus filter. Soluble iron and manganese are oxidized to the insoluble form and filtered out by a dual-media anthracite/GreensandPlus bed.

This same GreensandPlus process can also be effective for treating moderate levels of arsenic. Where it is suitable to apply this technology, the arsenic is easily oxidized and filtered out with the iron for up to a 95% removal of total arsenic. The MCL of 10 micrograms/liter, established in January 2002, can be easily met. Furthermore, local environmental authorities generally consider the waste stream from a GreensandPlus filter to be more favorable than those generated by activated alumina, ion exchange or RO technologies.

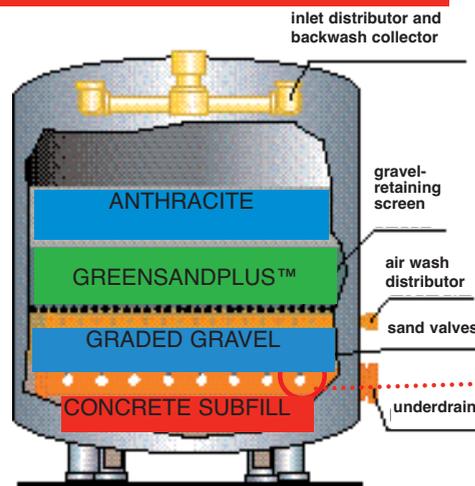
Due to the unique chemical and physical properties of GreensandPlus, attributable to the multivalent manganese oxide coating covering the sand grains, iron and manganese are consistently removed to levels required by the Safe Drinking Water Act or process requirements.

Manganese oxide has a well-known catalytic effect on the oxidation of soluble iron and manganese and also provides a redox buffer capable of either oxidizing remaining traces of iron and manganese or reducing excess KMnO_4 , if that is the oxidant being used. This not only ensures the consistent removal of iron and manganese, but also maintains the GreensandPlus in a continuously regenerated state without the need for separate KMnO_4 regeneration.

GreensandPlus IR for Manganese Removal

For groundwaters which contain only manganese or manganese with lesser amounts of iron, the intermittent regeneration (IR) process is recommended. It allows for extended run length with a minimum amount of head loss experienced during the filter run. In the IR method, a filter bed of GreensandPlus is periodically regenerated (in a manner similar to sodium-cycle softening) with a solution of chlorine or of KMnO_4 . The frequency of regeneration is a function of raw water manganese and the volume of water treated.

An illustration of a cross section of a typical Hungerford & Terry GreensandPlus Filtration system



During the service cycle, manganese is removed by utilizing the oxidative capacity of GreensandPlus. Oxidation of soluble manganese occurs directly on the GreensandPlus grains, becoming an integral part of the manganese oxide coating. To prevent fouling of GreensandPlus by the direct oxidation of soluble iron on the grains, varying amounts of accompanying iron should be oxidized using prechlorination prior to contacting the GreensandPlus bed. Normally, an IR filter will be designed with a bed consisting entirely of GreensandPlus. However, depending on the concentration of iron in the raw water, a dual media anthracite/GreensandPlus bed may be advantageous.

Either the CO or IR mode of operation consistently removes iron and manganese to levels which are equal to, or below, the Safe Drinking Water Act maximum contaminant levels (MCL).

Moreover, the GreensandPlus filter has proven itself as a cost-effective system with built-in flexibility for varying operating conditions.

This is why so many municipalities and industrial customers depend on H & T GreensandPlus filters. We encourage you to check our partial reference list as shown on the back cover and to contact us for additional reference installations.

For calculating specific chemical dosages and expected run lengths using the GreensandPlus process, refer to the Hungerford & Terry Technical Bulletin.

provide a number of different underdrain designs to meet this criteria based on either the engineer's or customer's specific requirements.

The optimum underdrain system is the header-lateral underdrain utilizing the time-proven H & T sand valve. For over 70 years, this nonclogging, noncorroding distributor has proven itself vastly superior to all others. Constructed of stainless steel with a Delrin¹ shank and Monel² splines, this distributor will provide years of trouble-free service without the problems inherent in some competitors' distributors.

In addition to the H & T sand valve underdrain, a nonferrous hub-radial lateral underdrain or header-lateral underdrain with drilled orifices may be provided.

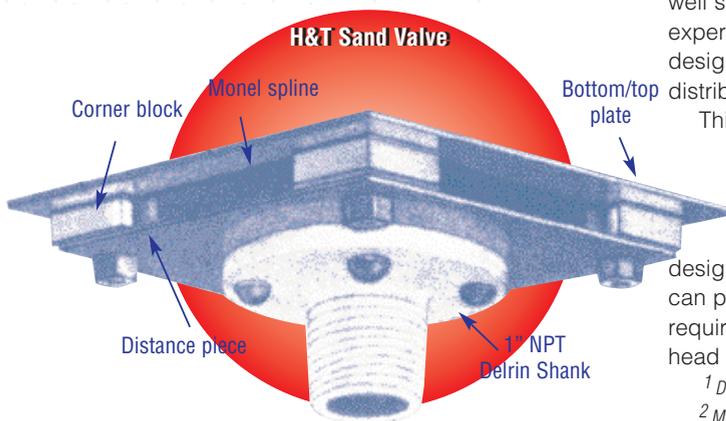
Although some equipment suppliers feature well screen-type strainers, our many years of experience make us reluctant to offer such a design. We have found that such strainer-type distributors may eventually become obstructed.

This results in disruption of the media bed, poor backwash distribution, and channeling – all requiring premature filter restoration.

With many years of experience in the design and manufacture of filter systems, H&T can provide the precise underdrain configuration required for optimum distribution with minimal head loss.

¹ Delrin is a registered trademark of E.I. DuPont.

² Monel is a registered trademark of International Nickel Co.



The exclusive Hungerford & Terry sand valve is available in stainless steel construction

Integral to either a GreensandPlus CO or IR system is a properly designed filtration unit capable of providing years of continued service. The following information provides an overview of the important design features of the Hungerford & Terry GreensandPlus filter.

The H & T Underdrain System

The underdrain system performs the dual function of backwash water distribution and filtered water collection and is the most critical aspect of a filter design. Hungerford & Terry can



Internal view of a horizontal filter with the underdrain installed prior to shipment.

The H & T Air/Water Wash System

In addition to the required backwash sequence, a supplemental air/water wash is often recommended to ensure that the filter bed is effectively cleaned of iron and manganese precipitates. Air discharged from either a lobe-type air blower or compressed plant air is used in conjunction with a simultaneous upflow water wash immediately prior to the full volume backwash. Design air rates are typically 0.8 to 2.0 CFM/sq. ft., depending on the filter type and raw water conditions. The simultaneous upflow wash should be maintained at 4 to 5 gpm/sq. ft. to provide the optimum air/water wash combination. This allows for vigorous contact and maximum scouring action between individual grains.

Surprisingly, an air/water wash step will generally add only 10 to 12 minutes to the backwash cycle of the CO filter or, in the case of an IR filter, the backwash/regeneration cycle. In general, the air/water wash sequence consists of draining the unit to the top of the filter bed, followed by the combination air/water wash which continues until the vessel is refilled. This is immediately followed with a full volume backwash for recommended time period of 8-10 minutes. Precipitates of iron and manganese are effectively loosened from the GreensandPlus grains during the air/water wash and then removed during the subsequent backwash.

H & T offers many designs to enable you to incorporate an air/water wash system into your GreensandPlus CO or IR filter. Our standard design calls for an air lateral grid located in the upper layers of the full graded gravel supporting bed. With this design, a gravel retaining screen is provided to prevent possible disruption of the gravel bed. This design allows for maximum effect of the air/water wash.

An air wash system can also be incorporated into an IR or CO filter using a number of different designs including a lateral grid located directly in the media bed or alternatively, directly through a hub radial or header lateral underdrain.

The H & T Gravel Retaining Screen

The H & T stainless steel gravel retaining screen is designed to secure the gravel supporting bed without hindering the necessary service or backwash flow distribution. Securing the gravel bed prevents it from becoming upset during either air wash operations or unpredictable backwash surges. As part of the GreensandPlus CO or IR filter, the H & T stainless steel retaining screen has proven its effectiveness and value in over half a century of service. We highly recommend it as part of the filter design.



This is an example of the 1.5 MGD municipal filter installation with air/water wash, by Hungerford & Terry.

H & T Partial List of Customers

	Capacity (MGD)	# of plants		Capacity (MGD)	# of plants
California American Water Co.	5.2 – 14.4	2	Town of Middletown	.81	2
Monterey, CA			Middletown, CT		
City of Zanesville	8	1	Iberville Parish Water	.21 – .67	3
Zanesville, OH			St. Gabriel, LA		
N.J. American Water	8	1	City of San Jacinto	.6	2
Camden, NJ			San Jacinto, CA		
City of Sulphur	.72 – 3.6	5	Town of Edgewood	1	1
Sulphur, TN			Edgewood, IN		
Sudbury Water District	0.7 – 3.66	2	Town of Havelock	3	2
Sudbury, MA			Havelock, NC		
Township of Freehold	.86 – 2.58	3	Town of Unionville	.43	1
Freehold, NJ			Unionville, CT		
Willmar MUA	1.44 – 2.16	2	Suffolk County Water Auth.	56	13
Willmar, MN			Oakdale, NY		
Town of Ocean City	.85 – 2.9	6	Town of Plainville	.34	1
Ocean City, MD			Plainville, MA		
Ore-Ida Food	2.02	1	American Electric Power	.25	1
Plover, WI			Glasgow, WV		
Novartis	1.5	1	Lake Charles Harbor	.22	1
East Hanover, NJ			Lake Charles, LA		
Ulster Water Dept.	1.5 – .58	2	Penn. Power & Light	.14	1
Ulster, NY			Berwick, PA		
City of Leesville, LA	1	1	Waterford Township	2.6	1
Leesville, LA			Waterford, Michigan		
City of Point Pleasant	.98	1	Onslow County Water System	4.0	2
Point Pleasant, WV			Onslow County, NC		
Nucor Steel	.15 – .95	1	Town of Sackville	1.9	1
Armored, AR			New Brunswick, Canada		



4,000 GPM Automatic Ferrosand filter installed in the municipal water works of Dover, Ohio.

Hungerford & Terry, Inc., has been designing and manufacturing water treatment systems for almost a century. We urge you to contact us for your specific treatment needs. We are ready to assist your engineering staff in pre-design and pilot plant studies, preliminary and final specifications development, as well as equipment start-up and training of operating personnel.



HUNGERFORD & TERRY, Inc.

226 Atlantic Ave. • PO Box 650
 Clayton, New Jersey 08312-0650
 Tel: 856.881.3200 • Fax: 856.881.6859
 email: sales@hungerfordterry.com