

MANGANESE GreensandPlus CM, CR, CO & IR PROCESSES

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Inversand Company
SINCE 1925

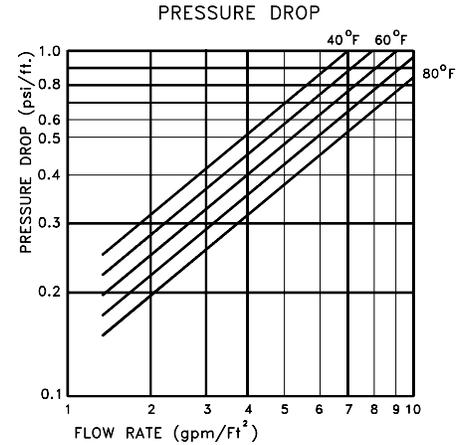
Manganese GreensandPlus, used for removing soluble iron, manganese and hydrogen sulfide from well water supplies, is a purple-black filter medium processed from a silica sand core.

GreensandPlus also has the capability of removing radium and arsenic from well waters. GreensandPlus systems may be designed using either vertical or horizontal pressure filters, as well as open gravity filters.

Manganese GreensandPlus is the proven technology for iron, manganese, and hydrogen sulfide removal. Unlike in-situ treated media, there is no need for extensive preconditioning of filter media or lengthy startup periods, during which required water quality may not be met.

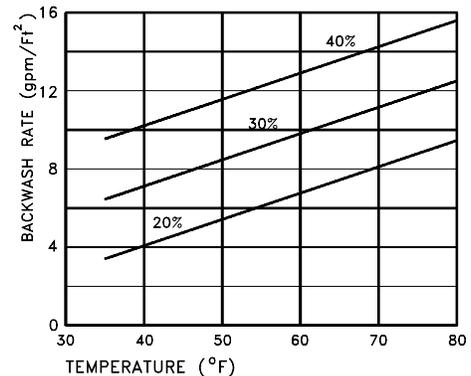
The unique chemical and physical characteristics of GreensandPlus allow flexibility of design using four methods of operation: catalytic process (CO), continuous regeneration (CM & CR), and intermittent regeneration (IR). The CR method is recommended for predominantly iron waters and the CO & IR methods may be used for groundwaters in which manganese predominates.

GreensandPlus has the WQA Gold Seal Certification for compliance with NSF/ANSI 61. Packaging is available in ½ cu. ft. bags or 1 metric ton (2,205 lbs) bulk sacks.



The approximate clean bed pressure drop for each foot of manganese GreensandPlus bed depth is shown above. Pressure drop increases as the service run progresses.

BED EXPANSION DURING BACKWASHING



Following a service cycle, the manganese GreensandPlus should be backwashed for 10 minutes with a minimum bed expansion of 40%. At a backwash water temperature of 12°C (55°F). This requires a 30 ml/h (12 gpm/ft²) backwash rate.

PHYSICAL CHARACTERISTICS of GreensandPlus

Physical form	Black nodular granules, shipped in a dry form
Apparent density	1,362 kg/m ³ (85 lbs/ft ³) net
Shipping weight	1,394 kg/m ³ (87 lbs/ft ³) net
Specific gravity	Approximately 2.4
Screen grading (dry)	18x60 mesh
Effective size	0.30 to 0.35 mm
Uniformity coefficient	Less than 1.60
pH range	6.2 - 8.5 (see note re pH)
Maximum temperature	Above 25° C (80°F) contact Ozogram Inc..
Maximum pressure drop	70 - 80 kPa (10 - 12 psi)
Backwash rate	Minimum 30 m/h (12 gpm/ft ²) at 12° C (55°F).
Service flow rate	10 m/h (2 - 5 gpm/ft ²)
Minimum bed depth	600mm (24") 400 - 450 mm (15-18") of each media for dual media beds.

CM or CR PROCESS

Continuous regeneration (CM/CR) processes are recommended for well waters where iron removal is the main objective with or without the presence of manganese. The CM method involves the feeding of only a predetermined amount of permanganate (MnO_4) while the CR method involves permanganate and chlorine (Cl_2), directly to the raw water before the greensand filter. Chlorine should be fed at least 10-20 seconds upstream of the MnO_4 , to produce the desired Cl_2 residual in the filter effluent. MnO_4 should be fed to produce a "just pink" colour in the filter inlet. This slight excess of MnO_4 or a Cl_2 residual carried through the filter will maintain the GreensandPlus in a continuously regenerated condition.

CM, $KMnO_4$ demand: MnO_4 (mg/L) = (1 x mg/L Fe) + (2 x mg/L Mn)

The two chemical reactions, for the oxidation of iron and manganese, are:
 $3Fe(HCO_3)_2 + KMnO_4 + 7H_2O \rightarrow MnO_2 + 3Fe(OH)_3 + KHCO_3 + 5H_2CO_3$
 $3Mn(HCO_3)_2 + KMnO_4 + 2H_2O \rightarrow 5MnO_2 + 2KHCO_3 + 4H_2CO_3$

CR, $KMnO_4$ demand: MnO_4 (mg/L) = (0.2 x mg/L Fe) + (2 x mg/L Mn)
 Cl_2 demand: Cl_2 (mg/L) = 1 x mg/L Fe + residual

The additional iron oxidation above is: $Fe^{2+} + Cl_2 \rightarrow Fe^{3+} + 2Cl^-$
 Finally, the greensand reduction of excess $KMnO_4$ applies to CM or CR above:
 $3Z \cdot MnO + 2KMnO_4 + H_2O \rightarrow 3Z \cdot MnO_2 + 2KOH + 2MnO_2$

The flow rate for these processes is generally 10 m/h (4-5 gpm/ft²).

(*) Permanganate (MnO_4) is available as ($KMnO_4$) potassium permanganate crystals, or as ($NaMnO_4$) sodium permanganate solution (40% MnO_4).

CO or IR PROCESS

The Catalytic (CO) process may be used for well waters where only manganese or manganese with small amounts of iron is to be removed. Manganese can be removed by the catalytic action of the manganese oxide coating on the GreensandPlus in the presence of chlorine. The higher valence manganese oxides are maintained in a regenerated condition by the oxidizing environment provided by the chlorine. No potassium permanganate is needed with a catalytic iron and manganese removal process.

CO, Cl_2 demand: Cl_2 (mg/L) = (1 x mg/L Fe) + (3 x mg/L Mn) + residual

The two chemical reactions, for iron and manganese, are:
 $Fe^{2+} + Cl_2 \rightarrow Fe^{3+} + 2Cl^-$
 $Cl_2 + Mn^{2+} \xrightarrow{Z \cdot MnO_2} MnO_2$, where $Z \cdot MnO_2$ is the manganese oxide catalyst.

The flow rate for the catalytic process is generally up to 20 m/h (6 to 8 gpm/ft²), twice as high as the CM, CR & IR processes.

The Intermittent (IR) method may also be used for well waters where only manganese or manganese with small amounts of iron is to be removed. It involves the regeneration of the GreensandPlus with a pre-determined amount of MnO_4 after a specified quantity of water has been treated. With this method, pressure drop is minimized as manganese is removed by contact oxidation on the grains of the GreensandPlus. Anthracite is not required if there is little or no iron present. Waste disposal could be a problem with this method.

The chemical reaction is: $Mn^{2+} + Z \cdot MnO_2 \rightarrow Z \cdot Mn_2O_3 + Mn^{+4}$

pH

Raw waters having a natural pH of 6.2 or above can be passed through manganese GreensandPlus without pH correction; water with a pH lower than 6.2 should be pH corrected to 6.2-6.5 before treatment with manganese greensand. If a pH higher than 6.5 is desired in the water system, the additional alkali should be added following the filters due to the possible adverse reaction (formation of a colloid) that sometimes occurs with the iron and alkali at a pH above 6.5.

Radium and Arsenic Removal

The GreensandPlus processes have been found to be successful in removing radium and arsenic from well water supplies. This occurs via absorption onto the manganese and/or iron precipitates that are formed. For radium removal, soluble manganese must be present in the raw water for removal to occur. Arsenic removal has been achieved with either iron or manganese being present in the raw water. Pilot plant testing is recommended in either case.

Bed Type

Dual media: Anthracite 300-450mm (12-18") and GreensandPlus 450-900mm (18-36"). 900mm (36") is used without anthracite for colloidal iron or manganese removal.

Pressure Drop

Maximum pressure drop: 70-80 kPa (10-12 psi).

Capacity

700-1200 grains of oxidized iron and manganese/ft² of bed area based on potassium permanganate demand. Some ground waters contain iron in a form that filters in depth and the pressure drop may not exceed 4-6 psi before iron appears in the filter effluent.

Backwash

Sufficient rate using treated water to produce 40% bed expansion. 30 m/h (12 gpm/ft²) is typical.

Air/Water Scour (Optional)

Using 250-600 L/min./m² (0.8-2.0 CFM/ft²) with a simultaneous treated water backwash at 10-12 m/h (4-5 gpm/ft²).

Raw Water Rinse

At normal service flow rate for 3-5 minutes or until effluent is acceptable.

Flow rate

Recommended flow rates with CM/CR processes are 5-12 m/h (2-5 gpm/ft²) and up to 20 m/h (8.2 gpm/ft²) in the CO process. Extremely high concentrations of iron and manganese usually require lower flow rates for equivalent run lengths. Higher flow rates can be considered with very low concentrations of iron and manganese. For optimum design parameters, pilot plant testing is recommended.

The run length between backwashes can be estimated as follows:

Run length for water containing 1.7 mg/L iron and 0.3 mg/L manganese at a 10 m/h (4 gpm/ft²) operating rate using a 0.1 m² (1 ft²) cross-sectional vessel:

Run length = Capacity / (MnO₄ demand x Flow)

Capacity	=	700 (grains/ft ²) x 1.0 ft ² x 17.1 (mg/L //grains/gal.)
MnO ₄ demand x flow	=	((1 x mg/L Fe) + (2 x mg/L Mn)) x 10 m/h (4 gpm)
Run length	=	$\frac{700 \times 1.0 \times 17.1}{2.3 \times 4 \times 60} = 21.7$ hours

The backwash frequency, to an 70-80 kPa (10-12 psi) pressure drop, is approximately every 20-22 hours of actual operation.

Suggested Operating Conditions for IR Process

Pressure Drop

Max. pressure drop of 70-80 kPa (10-12 psi). If maximum pressure differential is reached before the removal capacity of Mn is obtained, manganese greensand may be backwashed without regeneration.

Capacity

400 grains Mn/ft³. Prechlorination is recommended especially if iron is present.

Backwash

Sufficient rate to produce 40% bed expansion.

Air/Water Scour

Recommended using 250-600 L/min./m² (0.8-2.0 cfm/ft²) with a simultaneous treated water backwash at 10-12 m/h (4-5 gpm/ft²).

Flow Rate

2.5 gpm/ft², or 1-2 gpm/ft³.
For high flow rates contact supplier.

Regeneration

$KMnO_4$ Dosage	1.5 - 2 kg/m ³ (1.5-2.0 oz/ft ³)
$KMnO_4$ Stock solution strength	15-30 grams/L (2-4 oz/gal)
$KMnO_4$ Regeneration volume	1,000 L/m ³ (7.5 gal/ft ³)
$KMnO_4$ Regeneration rate	33 L/m (0.25 gpm/ft ³)
$KMnO_4$ Regeneration time	30 minutes optimum
Rinse Rate (raw water)	125 L/min/m ³ (1 gpm/ft ³)
Rinse Volume	6,000 L/m ³ (40-50 gal/ft ³) or until all traces of $KMnO_4$ are gone.