TECHNICAL REPORT:

REMOVING IRON FROM MANKATO MUNICIPAL DRINKING WATER

AUTHOR

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INTRODUCTION

Mankato, Minnesota, is located within the counties of Blue Earth, Nicollet, and Suer in the Upper Midwest region of the United States. It has a population of 44,488 according to the 2020 census, making it the 21st largest city in Minnesota.

Mankato municipal drinking water is considered to be safe and of good quality. However, the ferrous iron content is above the WHO's (World Health Organization) recommended maximum level of 0.30 ppm. Current treatment of the city water includes oxidation of the ferrous iron by chlorination followed by filtration. Manganese, a contaminant that is often present together with iron, is not present in Mankato's drinking water.

Raw Water Chemical Composition	
Total Hardness	270 - 308 ppm as $CaCO_3$
Alkalinity	320 - 370 ppm as $CaCO_3$
Copper (Cu^{+2})	0.1 ppm
Ferrous Iron (Fe^{+2})	2.0 – 2.4 ppm
Ferric Iron (Fe^{+3})	0.0 ppm
Nitrate (NO_3)	2.0 – 2.4 ppm
pH	7.0 – 7.2

RESINTECH® INC.
INNOVATIONS IN ION EXCHANGE

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RESINTECH SIR-1300

ResinTech **SIR-1300** is a new hybrid ion exchange resin formulated to remove iron and manganese. It is part of the ResinTech SIR (Selective Ion Resin) line of products.

The SIR-1300 technology is based on manganese oxide mono-atomically dispersed within the bead's polymeric structure. The resultant hybrid ion exchange resin is able to react instantaneously with ferrous iron in the presence of oxygen.

The SIR-1300's chemical mechanism is as follows:

Oxygen loading: Initial form

$$[\text{SIR-1300}]\text{-}6\text{MnO} + 3\text{O}_2 \longrightarrow [\text{SIR-1300}]\text{-}6\text{MnO}_2$$

Exhaustion cycle: Final form

$$[\text{SIR-1300}]\text{-}6\text{MnO}_2 + 4\text{Fe}^{+2} \longrightarrow [\text{SIR-1300}]\text{-}6\text{MnO} + 2\text{Fe}_2\text{O}_3$$

Oxygen loading: Back to the initial form

$$[\text{SIR-1300}]\text{-}6\text{MnO} + 3\text{O}_2 \longrightarrow [\text{SIR-1300}]\text{-}6\text{MnO}_2$$

The SIR-1300 requires an oxygen loading of 60 to 80 grams of oxygen per cubic meter of resin (2.11 to 2.82 ounces of oxygen per 35 cubic feet of resin) for effective regeneration. The oxygen source is environmental air, free of oil, injected at 1 to 2 BARS (14.5 to 29 PSI) for medium to large equipment. For small units containing 28.32 to 283.20 liters of resin (1 to 10 cubic feet), the air can be injected via an inline eductor. The process of oxygen loading is through air scouring.

This process is divided into two steps:

- Upflow air scouring cleanup process required to break up the Fe_2O_3 crust formed during the catalytical iron oxidation process.
- Upflow oxygen loading through the bed of SIR-1300 for the oxygen fixation process across the bead's inner and outer surface.

After the upflow air scouring process, a backwash step is required to remove the precipitated Fe_2O_3 from the SIR-1300 resin bed. The backwash step should be 10 to 15 minutes at a flow velocity of 14.7 m/h (6 gpm/square foot) with air injection. The required bed expansion is about 40%.

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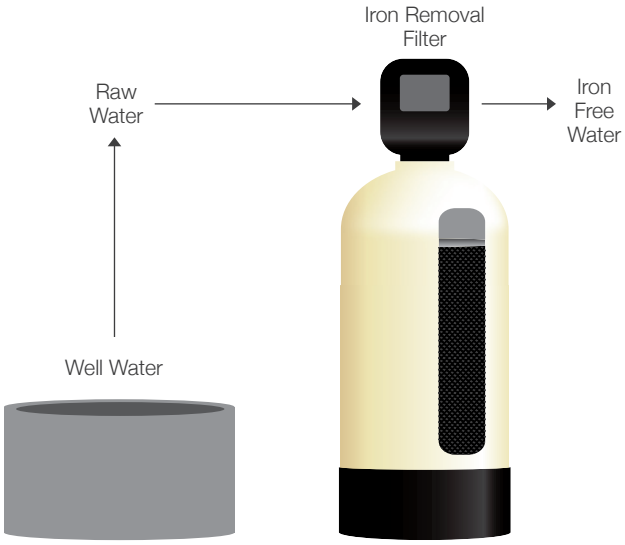
PILOT STUDY

A pilot plant was installed in Miller, within the Mankato City urban area. The water source was a well, 30.4 meters (99 feet) deep. The service flow rate was 1.14 m3/h (5 gpm).

Site Water Composition	
Total Hardness	307 ppm as $CaCO_3$
Alkalinity	370 ppm as $CaCO_3$
Copper	0.1 ppm
Ferrous iron	2.0 ppm
pH	7.1

The pilot plant arrangement was an FRP vessel controlled by an automatic valve head. The schematic of the field trial arrangement is below.



Iron removal filter

- *Vessel diameter:* 254 mm (10")
- *Vessel height:* 1,371.6 mm (54")
- *Inlet/Outlet size:* 1 ¼"
- *Eductor size:* ¼"

Type of media: ResinTech SIR-1300

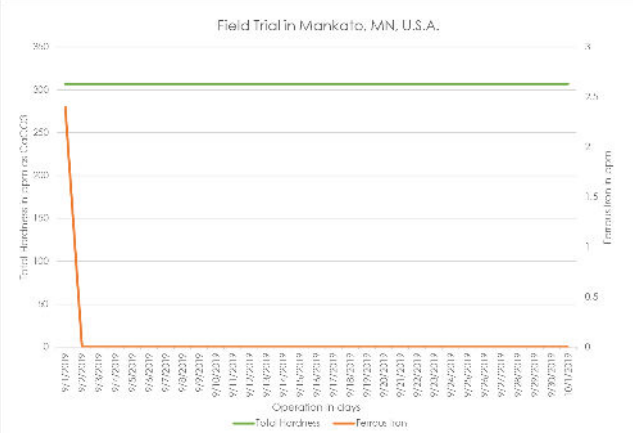
Volume: 42.5 liters (1.5 cubic feet)

Automatic valve head: Clack Water Specialist EE1.25

Operational cycle: 12 hours

FIELD TEST RESULTS

The field trial was conducted for an entire month and controlled daily, by sample control, every hour. At the end of each 12 hour service cycle, the unit was automatically air scoured (upflow) for 15 minutes. This was followed by a 20 minute backwash together with air injection for removal of the precipitated ferric iron from the resin bed. The air injection was performed by the eductor in the automatic valve head.



SUMMARY

The observed results were consistent with the calculated performance that was performed for the SIR-1300 by the ResinTech Technical Department prior to the pilot test. The media produced treated water with a non-detect level of ferrous iron in the effluent. This quality was maintained during each 12 hour service cycle throughout the entire month of testing.

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