TECHNICAL BULLETIN: Wastewater

Ferric Salts in Water and Wastewater Applications

Ferric salts are used in many different municipal and industrial applications. In water and wastewater treatment operations, ferric salts are used as coagulants or flocculants, for odor control to minimize hydrogen sulfide release, for phosphorus removal, and as a sludge thickening, conditioning and dewatering agent.

Municipal wastewater treatment facilities can apply ferric salts near or at the headworks or in tertiary treatment systems to reduce hydrogen sulfide for both odor control and to minimize exposure to dangerous gas levels. Phosphorus reduction is achieved through the formation and sedimentation of ferric orthophosphate ($FePO_4$). Prior to conventional or high rate (stormwater) clarifiers, ferric salts coagulate suspended solids for efficient settling and clarification. As a pre-conditioner to liquid-solids separation (dewatering), ferric salts, under specific conditions, reduce the dosage of polymer used for flocculation of solids. The flocs formed with ferric salt pre-conditioning tend to be denser, thus providing faster drainage and improved sludge conditioning for higher applied pressure or shear forces.

Ferric Salts

The two most utilized ferric salts are ferric sulfate and ferric chloride, commonly sold and applied in a liquid form.

Liquid ferric sulfate is a red-brown aqueous solution that is typically sold as a 50% or 60% strength solution. Based on ferric iron (Fe^{+3}) contents of 10% and 12% respectively, the formula for dry ferric sulfate would be $Fe_2(SO_4)_3 \bullet 8.8H_2O$. The maximum concentration as ferric iron is approximately 13% in commercial liquid products.

Liquid ferric chloride is also a red-brown solution. The strengths of ferric chloride solution are usually expressed as anhydrous ferric chloride, $FeCl_3$, which ranges from 28% to 45% as $FeCl_3$ in commercial solutions, with 39% being the most typical concentration. The ferric iron equivalent to these solution concentrations are a range from 9.7 to 15%, with a typical value of 13.4% as Fe^{+3}.

The advantages of ferric sulfate vs. ferric chloride solutions begin with the compatibility of the iron salts with metals. Ferric chloride is overall more corrosive than ferric sulfate. Even though both solutions are listed as Class 8 Corrosives, liquid ferric sulfate is compatible with Type 316 Stainless Steel, commonly used in many processes for storage tanks, piping, valves, fittings and pump wetted parts. Ferric sulfate solutions are also compatible with Alloy 20 and Hastelloy C-276, two of the more commonly used alloy metals in industrial process systems.

Ferric chloride solution is not compatible with Type 316 Stainless or Alloy 20, however is compatible with Hastelloy C-276 up to a temperature of 38°C (100°F).

Impurities such as heavy metal contaminants can be more prevalent with liquid ferric chloride, depending upon the source of the solution. Most ferric chloride solutions are byproducts or waste streams of various manufacturing processes, including the pickling of steel, of which ferric chloride solution is a waste liquor.

Liquid ferric sulfate is commonly manufactured through the use of a virgin iron ore and sulfuric acid, resulting in much lower levels of trace metal contaminants in the product. Potable water treatment plants have successfully switched from liquid ferric chloride to liquid ferric sulfate for the reduction of various substances, including manganese (Mn), to reduce the levels of these substances in the process sludge.

References

1. Corrosion Resistance Tables, Philip A. Schweitzer, P.E., Third Edition, 1991, pgs. 1041-1048 and 1057-1060.

Typical Chemical Properties	**60% Ferric Sulfate**	**39% Ferric Chloride**
Soluble Ferric Iron (Fe^{+3})	12%	13.4%
Soluble Ferrous Iron (Fe^{+2})	less than 0.2%	less than 1.3%
Free Acid	less than 3% (as H_2S0_4)	less than 4% (as HCl)
Water Insolubles	less than 0.1%	less than 0.5%
Product Density	13.18 lbs./US gallon	11.71 lbs./US gallon
pH, as is	1.0 (approx.)	less than 1.0
Specific Gravity (at 15.6°C/60°F)	1.580	1.403
Freezing Temperatures	less than -50°C (< -58°F)	-12°C (10°F)
Boiling Temperatures	100°C (212°F) (approx.)	106°C (223°F) (approx.)

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