Ferric Sulfate

$Fe_2(SO_4)_3$

Direct Use Chemical

(liquid, solid)

Inputs to Manufacturing Process:
Chlorine
Ferrous Sulfate
Sulfuric Acid

% of Total Domestic Consumption Attributed to Water Sector:
Greater than 50%

Product Family:
Chlor-alkali
Iron

CAS No.: 10028-22-5

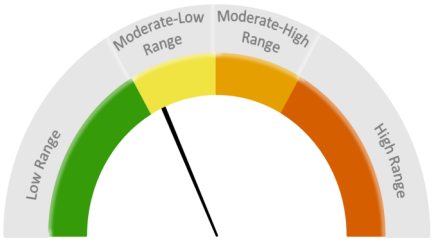
Derivative Water Treatment Chemicals:
None

Understanding Chemical Supply Chains
Map of Suppliers & Manufacturers

Shelf Life:
12 Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Moderate-Low



RISK DRIVERS

Production of ferric sulfate depends on the steel industry, and production of sulfuric acid and chlorine for manufacturing inputs. Decreased demand for steel and fluctuating availability of sulfuric acid and chlorine may influence the price for ferric sulfate.

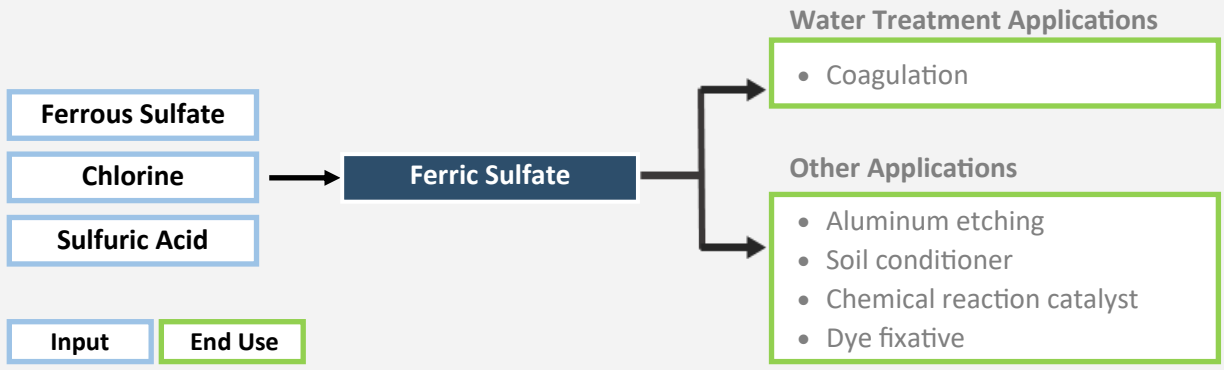
RISK PARAMETERS

Criticality: High. Essential for coagulation.

Likelihood: Moderate-Low. Previous significant price increases have impacted the water sector.

Vulnerability: Low. Distributed domestic manufacturing and supply. Reliance on chlor-alkali and steel industries may increase vulnerability.

MANUFACTURING PROCESS



DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

Domestic Manufacturing Locations (2015):
11, distributed throughout the U.S.

International Trade (2019)

Primary Trading Partner (Imports): China

Primary Trading Partner (Exports): Canada

Domestic Production and Consumption

Total domestic manufacturing of ferric sulfate reported under the TSCA CDR was approximately 266 M kg in 2019. Significantly, several domestic manufacturers of ferric sulfate did not report production. Due to this data gap and differences in reporting between production and trade data, U.S. consumption of ferric sulfate could not be estimated.

Product Description

Ferric sulfate ($Fe_2(SO_4)_3$), a highly corrosive and acidic compound, is widely used in agriculture and chemical production. In water treatment, it is a commonly used coagulant. Ferric sulfate is primarily made from ferrous sulfate, commonly produced as a byproduct of steel pickling. Water treatment applications are the primary commercial use of ferric sulfate in the U.S.

Use in Water Treatment

Ferric sulfate is used as a coagulant in both drinking water and wastewater treatment (AWWA, 2014).

Use as a Precursor to Other Water Treatment Chemicals

Ferric sulfate is not used to manufacture other water treatment chemicals.

Other Applications

Ferric sulfate is used for aluminum etching, as a soil conditioner, a polymerization catalyst, a dye fixative, and as a hemostatic agent in dentistry (NCBI, 2021).

Primary Industrial Consumers

A considerable amount of the ferric sulfate produced worldwide is used in water treatment. Historically, water treatment has been the primary domestic use of ferric sulfate (NCBI, 2021).

Manufacturing, Transport, & Storage

Manufacturing Process

Ferric sulfate is primarily produced through a reaction of ferrous sulfate, sulfuric acid, and an oxidant such as chlorine, nitric acid, or hydrogen peroxide. The equation shown in Figure 1 demonstrates the method of production where chlorine is used as an oxidizing agent (NCBI, 2021). Production starts with a solution of ferrous sulfate, which is commonly produced through the process of steel pickling. Ferrous sulfate derived as a byproduct of acid leaching of ilmenite to recover titanium dioxide is a less common source of ferrous sulfate in North America. The manufacturing process for ferrous sulfate production through steel pickling and iron oxide leaching from ilmenite are described in the ferrous sulfate supply chain profile (EPA, 2022a). Using an oxidant such as chlorine, ferrous sulfate is oxidized to ferric sulfate with controlled addition of sulfuric acid.

Ferrous Sulfate	+	Sulfuric Acid	+ Chlorine Gas	→	Ferric Sulfate	+	Hydrochloric Acid
$2FeSO_4$	+	H_2SO_4	+ Cl_2	→	$Fe_2(SO_4)_3$	+	2HCl

Figure 1. Chemical Equation for the Reaction to Manufacture Ferric Sulfate

Product Transport

Ferric sulfate is commonly transported by truck, rail, barge, and ship (Chemtrade Logistics, 2020).

Storage and Shelf Life

Ferric sulfate is stable under recommended storage conditions, but degrades when exposed to direct sun and heat. When stored properly, ferric sulfate can have a shelf life of approximately twelve months, though stability may depend upon many factors (Chemtrade Logistics, 2020).

Domestic Production & Consumption

Domestic Production

Production data was collected from the 2020 Toxic Substances Control Act (TSCA) Chemical Data Reporting (CDR) for the year 2019, while trade data was collected from the U.S. International Trade Commission (USITC) Dataweb, as shown in Table 1. While production data is specific to ferric sulfate, trade data includes ferric sulfate as part of a broader trade category of metal sulfates. For imports, the trade category is specific to iron sulfates, while the export trade category includes ferric sulfate among metal sulfates, 'not elsewhere specified' (NES).

Table 1. Chlorine Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source**	**Identifier**	**Description**
Domestic Production	2020 TSCA Chemical Data Reporting	CAS No.: 10028-22-5	Ferric Sulfate
Imports and Exports	U.S. International Trade Commission	HTS Code (Imports): 2833.29.2000 HS Code (Exports): 2833.29	Iron Sulfates Metal Sulfates, NES

Total U.S. domestic manufacturing of ferric sulfate reported under the CDR was approximately 266 million kilograms (M kg) in 2019 (EPA, 2020). Domestic commercial manufacture of ferric sulfate takes place at select facilities located throughout the contiguous U.S. Primary producers include *Chemtrade Logistics*, *Kemira Water Solutions*, and *Thatcher Chemical*. Most ferric sulfate production facilities rely on the availability of ferrous sulfate and an oxidant such as chlorine, nitric acid, or hydrogen peroxide. The number of domestic manufacturing locations shown in Figure 2 represents operating facilities as of 2015 (EPA, 2016). Supply of NSF/ANSI Standard 60 certified ferric sulfate for use in drinking water treatment is widely distributed throughout the U.S. (NSF International, 2021). For a more current listing of manufacturing locations and supplier locations, visit the U.S. Environmental Protection Agency's (EPA's) Chemical Locator Tool (EPA, 2022b).

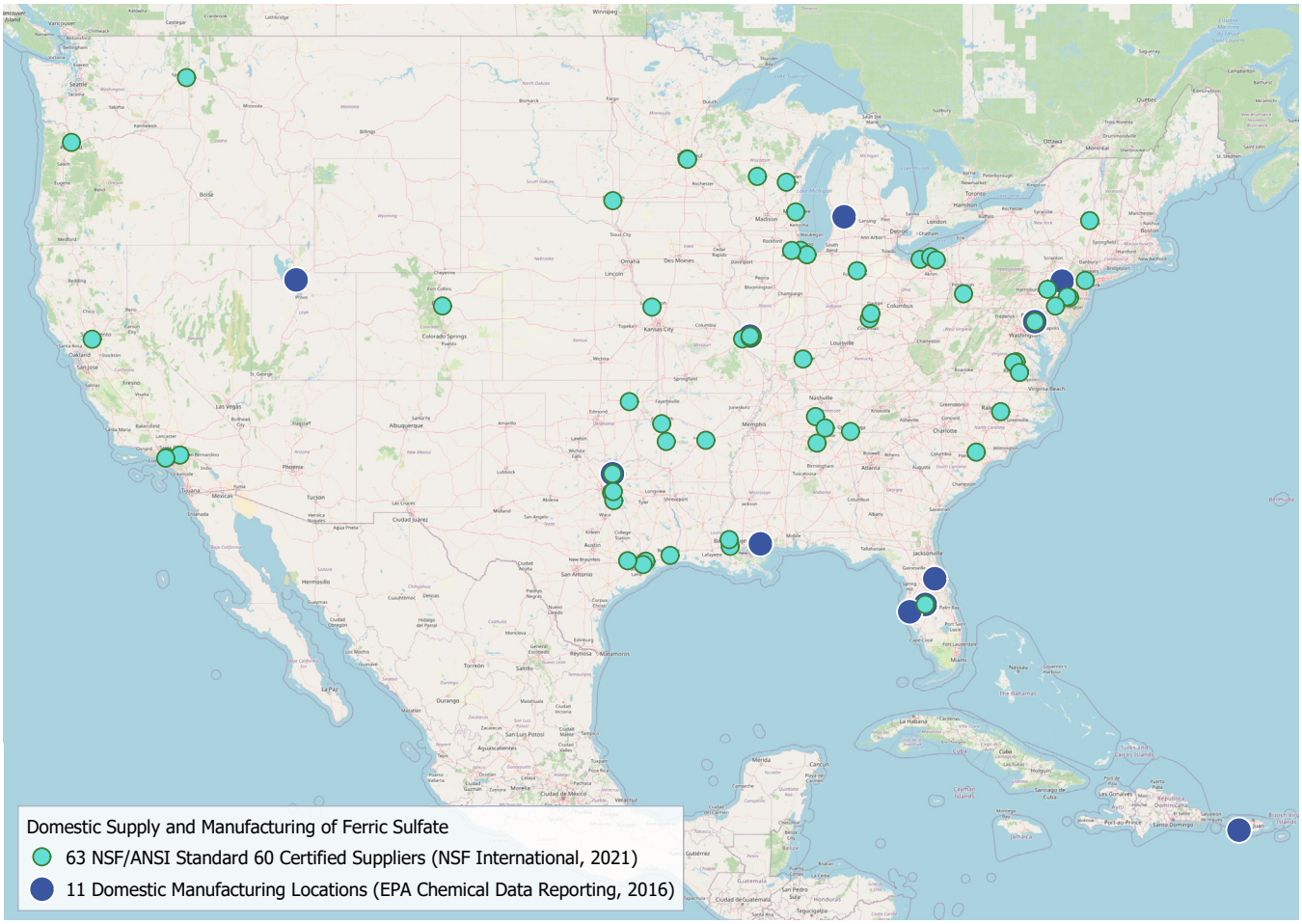


Figure 2. Domestic Supply and Manufacturing of Ferric Sulfate

Domestic Consumption

Due to differences in reporting for production and trade data, as well as the significant number of producers that did not report production data under the CDR, U.S. consumption of ferric sulfate could not be estimated. Domestic production of ferric sulfate may represent an unknown quantity of the import and export volume for the category of metal sulfates including ferric sulfate.

Trade &Tariffs

Worldwide Trade

Worldwide import and export data for ferric sulfate are reported through the World Bank's World Integrated Trade Solutions (WITS), as a category representing metal sulfates, NES. In 2021, the U.S. ranked 18th worldwide in total exports and second in total imports of metal sulfates, NES. In 2021, Germany ranked first worldwide in total exports and imports (WITS, 2022), as shown in Table 2. Import and export data specific to ferric sulfate is unavailable from the referenced sources.

Table 2. WITS Worldwide Export and Import of Metal Sulfates, NES, Including Ferric Sulfate in 2021

2021 Worldwide Trade Metal Sulfates, NES (HS Code 2833.29)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
Germany	836 M kg	Germany	348 M kg
China	636 M kg	**United States**	**267 M kg**
Poland	257 M kg	Austria	144 M kg
Spain	129 M kg	United Kingdom	99 M kg
Slovenia	119 M kg	Sweden	93 M kg

Domestic Imports and Exports

Domestic imports and export data are reported by USITC in categories for metal sulfates. For imports, the trade category is specific to iron sulfates, while the export trade category includes sulfates NES. Figure 3 summarizes imports for consumption[1] and domestic exports[2] between 2015 and 2020. During this period, the overall quantity of imports varied between 62 and 94 M kg. The quantity of exports was consistently much smaller than the quantity of imports. Over this five-year period, Canada was the primary recipient of domestic exports while China replaced Canada and Spain as the primary source of imports (USITC, 2021).

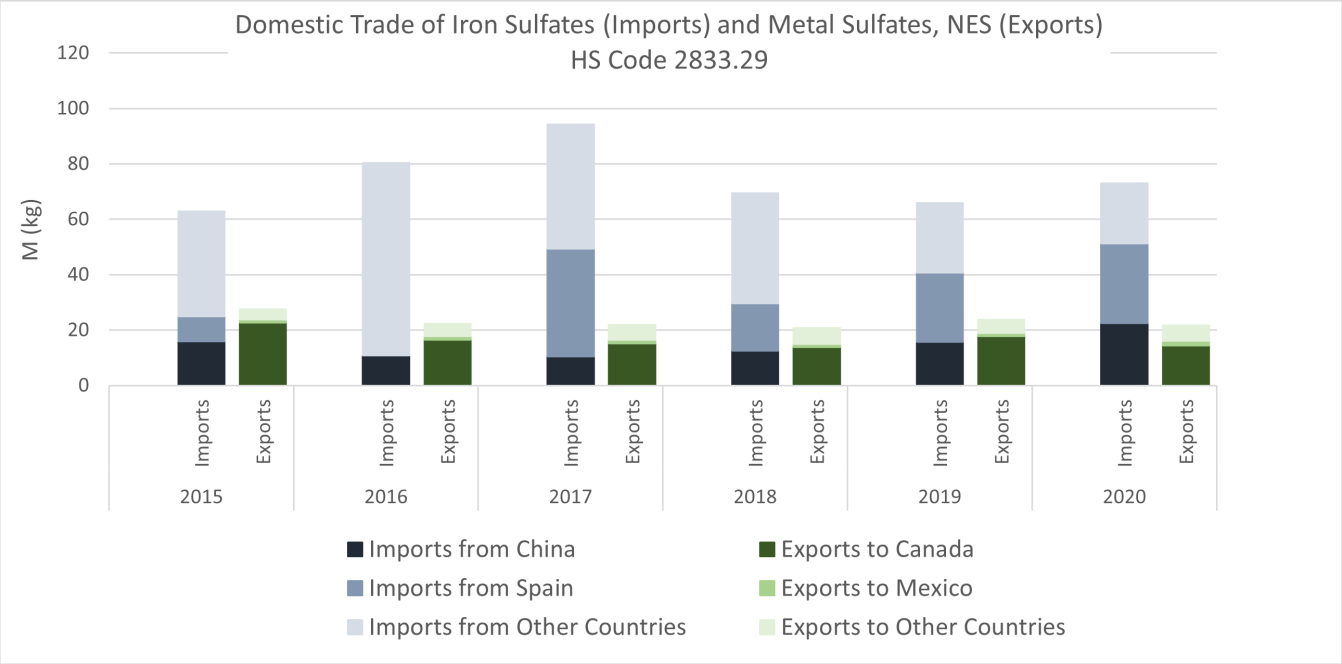


Figure 3. USITC Domestic Import and Export of Iron Sulfates between 2015 and 2020

[1] Imports for consumption are a subset of general imports, representing the total amount cleared through customs and entering consumption channels, not anticipated to be reshipped to foreign points, but may include some reexports.

[2] Domestic exports are a subset of total exports, representing export of domestic merchandise which are produced or manufactured in the U.S. and commodities of foreign origin which have been changed in the U.S.

Tariffs

There is no general duty for import of iron sulfates, however there is an additional 25% duty on imports from China (USITC, 2022), as summarized in Table 3.

Table 3. 2021 Domestic Tariff Schedule for Iron Sulfates

HTS Number	General Duty	Additional Duty - China (Section 301 Tariff List)	Special Duty
2833.29.2000	None	25%	None

Market History & Risk Assessment

History of Shortages

The production of ferric sulfate in North America is heavily reliant on the steel industry for the precursor, ferrous sulfate, as well as supply of sulfuric acid and chlorine. Economic slowdowns and a drop in domestic steel manufacturing along with greater recycling of steel pickling liquor and availability of chlorine have been known to impact the availability of ferric sulfate and have led to significant price fluctuations for ferric sulfate.

Risk Evaluation

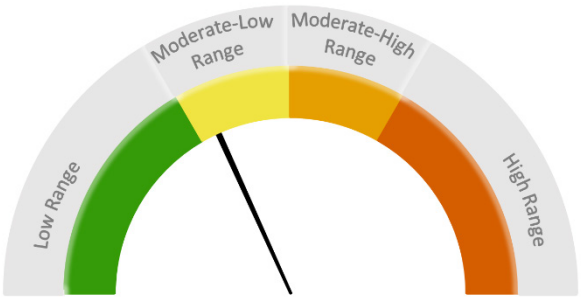
The complete risk evaluation methodology is described in *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions* (EPA, 2022c). The risk rating is calculated as the product of the following three risk parameters:

Risk = Criticality x Likelihood x Vulnerability	
Criticality	Measure of the importance of a chemical to the water sector
Likelihood	Measure of the probability that the chemical will experience a supply disruption in the future, which is estimated based on past occurrence of supply disruptions
Vulnerability	Measure of the market dynamics that make a chemical market more or less resilient to supply disruptions

The individual parameter rating is based on evaluation of one or more attributes of the chemical or its supply chain. The ratings and drivers for these three risk parameters are shown below in Table 4.

Table 4. Supply Chain Risk Evaluation for Ferric Sulfate

Risk Parameter Ratings and Drivers		
Criticality: High	**Likelihood: Moderate-Low**	**Vulnerability: Low**
Ferric sulfate is an essential water treatment chemical, widely used as a coagulant.	The water sector has experienced significant price increases in the past, but has not experienced supply chain disruptions between 2000 and 2022.	Strong domestic manufacturing capabilities and a distributed manufacturing base provide some resilience to supply disruptions. However, the reliance on supply from both the chlor-alkali and steel industries may increase vulnerability.
Risk Rating: Moderate-Low		



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