Ferric Chloride

$FeCl_3$

Direct Use Chemical

(liquid, solid)

Inputs to Manufacturing Process:
Chlorine
Ferrous Chloride

% of Total Domestic Consumption Attributed to Water Sector:
Approximately 80%

Product Family:
Chlor-alkali
Iron

CAS No.: 7705-08-0

Derivative Water Treatment Chemicals:
None

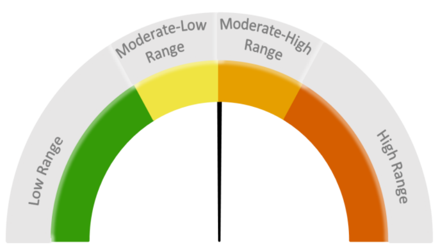
[Understanding Chemical Supply Chains]

[Map of Suppliers & Manufacturers]

Shelf Life:
6-12 Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: **Moderate-Low**



RISK DRIVERS

Production of ferric chloride depends on the steel and chlor-alkali industries to produce manufacturing inputs. Unplanned and planned reductions in chlor-alkali production capacity and decreased demand for steel have reduced the supply of ferric chloride.

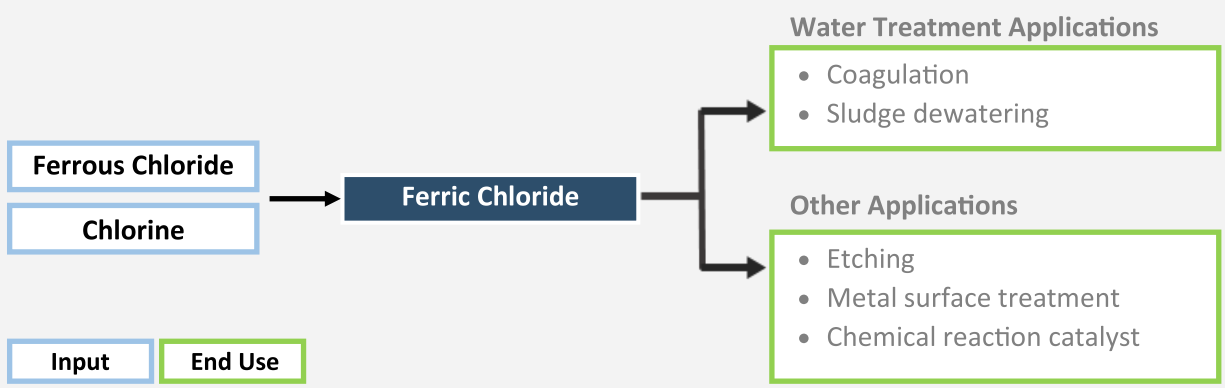
RISK PARAMETERS

Criticality: High. Essential for coagulation and dewatering.

Likelihood: High. Previous regional disruptions in supply that impacted the water sector.

Vulnerability: Low. Distributed domestic manufacturing and supply.

MANUFACTURING PROCESS



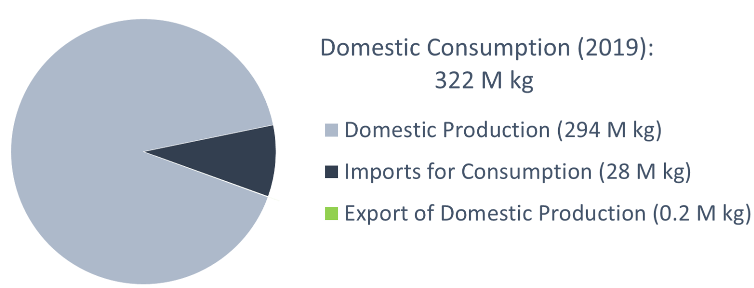
DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

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

International Trade (2019)

Primary Trading Partner (Imports): Canada

Primary Trading Partner (Exports): Thailand



EPA

Product Description

Ferric chloride ($FeCl_3$), an inorganic iron salt, is a widely used coagulant and dewatering agent. It is primarily produced as a byproduct of steel pickling, a process that relies on iron oxide, hydrochloric acid, and chlorine. Water treatment applications are the primary commercial use of ferric chloride in the U.S.

Use in Water Treatment

Ferric chloride is used as a coagulant in both drinking water and wastewater treatment and as a sludge dewatering agent (NCBI, 2021).

Use as a Precursor to Other Water Treatment Chemicals

Ferric chloride is not used as a precursor in the commercial manufacture of other water treatment chemical.

Other Applications

Ferric chloride is used for electronic and photographic etching, metal surface treatment, and as a catalyst in chemical reactions for products such as vinyl chloride (NCBI, 2021).

Primary Industrial Consumers

A considerable amount of the ferric chloride produced worldwide is used in water treatment. It has been estimated that 80% of domestic consumption of ferric chloride is used in water treatment, with the majority used in wastewater treatment (NCBI, 2021).

Manufacturing, Transport, & Storage

Manufacturing Process

Ferric chloride can be produced with a number of starting materials. Production may start with the process of steel pickling or with a solution of ferrous chloride produced through steel pickling. Ilmenite, the raw material used to produce titanium dioxide, can also be used but is a less common source of iron oxide in North America.

The method most commonly used in North America utilizes a reaction of spent steel pickling liquors with hydrochloric acid, followed by subsequent chlorination of the product (AWWA, 2012). Pickling of steel removes the surface mixed iron oxides through immersion in a bath containing either a sulfuric or hydrochloric acid solution. As described in the manufacturing process for the ferrous chloride supply chain (EPA, 2022a), when hydrochloric acid is used the mixed oxides in the oxidation layer of the steel as well as the underlying iron react with the hydrochloric acid to form ferrous chloride. The solution is reacted with additional hydrochloric acid to produce ferrous chloride with a higher iron and lower acid concentration. The solution is filtered and chlorinated, resulting in production of a concentrated ferric chloride solution, as shown in Figure 1 (Alcaraz et al., 2021; Michigan DEQ, 2015; Özdemir, et. al, 2006).

Ferrous Chloride	+	Chlorine	→	Ferric Chloride
$2FeCl_2$	+	Cl_2	→	$2FeCl_3$

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

Ilmenite, the raw material used to produce titanium dioxide can also be used but is a less common source of iron oxides in North America. Production as a byproduct of the manufacture of titanium dioxide results from the process to remove the iron oxide impurities present in low-grade titanium ore such as ilmenite. Iron oxides can be removed through a process of selective chlorination, which involves heating the titanium ore in the presence of additional carbon and chlorine gas and results in titanium tetrachloride, carbon monoxide, and ferric chloride (EPA, 2001; Habashi et al., 2014; Jung et al., 2021).

Product Transport

Ferric chloride may be transported in bulk or container by truck, rail, and ship (LabChem, 2017).

Storage and Shelf Life

Ferric chloride is corrosive and acidic, and as such should be stored in corrosion-resistant container in a cool, dry area. When stored properly, ferric chloride can have a shelf life of approximately 6-12 months (LabChem, 2017; SalChem, 2015).

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 chloride, trade data includes ferric chloride as part of the trade category for iron chlorides.

Table 1. Ferric Chloride Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source**	**Identifier**	**Description**
Domestic Production	2020 TSCA Chemical Data Reporting	CAS No.: 7705-08-0	Ferric Chloride
Imports and Exports	U.S. International Trade Commission	HTS Code: 2827.39.55	Iron Chlorides, including Ferric Chloride

Total U.S. domestic manufacturing of ferric chloride reported under the CDR was approximately 322 million kilograms (M kg) in 2019 (EPA, 2020). Domestic commercial manufacture of ferric chloride takes place at select facilities located throughout the contiguous U.S. Primary producers include *PVS Technologies, Inc*., and *Kemira Water Solutions*. Most ferric chloride production facilities rely on the availability of chlorine and hydrochloric acid, as well as scrap steel. 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 chloride 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).

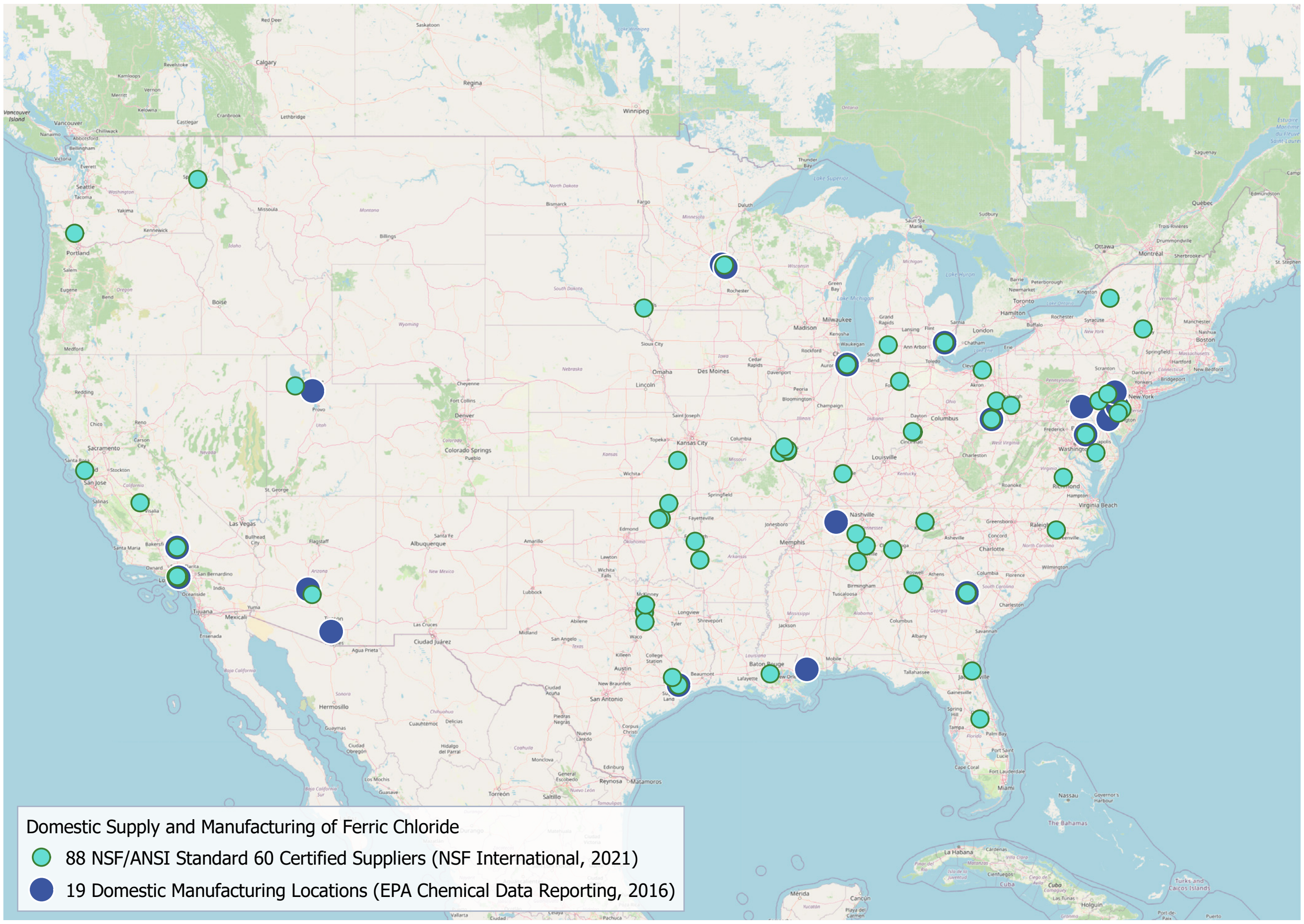


Figure 2. Domestic Supply and Manufacturing of Ferric Chloride

Domestic Consumption

U.S. consumption of ferric chloride in 2019 is an estimate based on production of ferric chloride and trade of a broader category of iron chlorides. Trade of ferric chloride is an unknown percentage of import and export volume in this category. This estimate includes production of 294 M kg, import of 28 M kg, minus export of 0.2 M kg (EPA, 2020; USITC, 2021), as shown in Figure 3. Imports and exports represent small quantities when compared to domestic production.

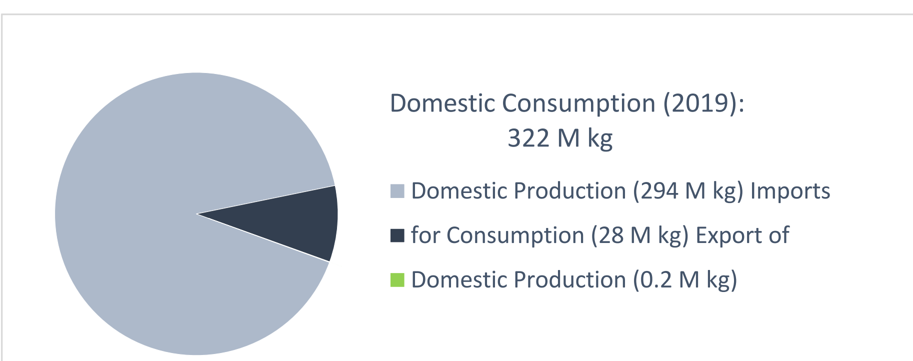


Figure 3. Domestic Production and Consumption of Ferric Chloride in 2019

Trade &Tariffs

Worldwide Trade

Worldwide import and export data for ferric chloride are reported through the World Bank's World Integrated Trade Solutions (WITS), as a category representing metal chlorides of tin, barium, iron, cobalt, and zinc. In 2021, the U.S. ranked 14th worldwide in total exports and 8th in total imports of metal chlorides. In 2021, Germany ranked first worldwide in total exports (WITS, 2022), as shown in Table 2. Import and export data specific to ferric chloride are unavailable from the referenced sources.

Table 2. WITS Worldwide Export and Import of Metal Chlorides, Including Ferric Chloride in 2021

2021 Worldwide Trade Metal Chlorides of Tin, Barium, Iron, Cobalt, Zinc (HS Code 2827.39)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
Germany	194 M kg	Netherlands	79 M kg
China	110 M kg	France	78 M kg
France	84 M kg	India	76 M kg
Belgium	79 M kg	Belgium	75 M kg
India	71 M kg	Germany	69 M kg

Domestic Imports and Exports

Domestic imports and export data are reported by USITC in categories inclusive of all iron chlorides. Figure 4 summarizes imports for consumption[1] and domestic exports[2] of iron chlorides between 2015 and 2020. During this period, the overall quantity of imports grew steadily. The overall quantity of exports was much smaller than the quantity of imports, with average values of 0.4 M kg and 19.2 M kg, respectively. Over this five-year period, Thailand was the primary recipient of domestic exports while Canada was the primary source of imports (USITC, 2021).

[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.

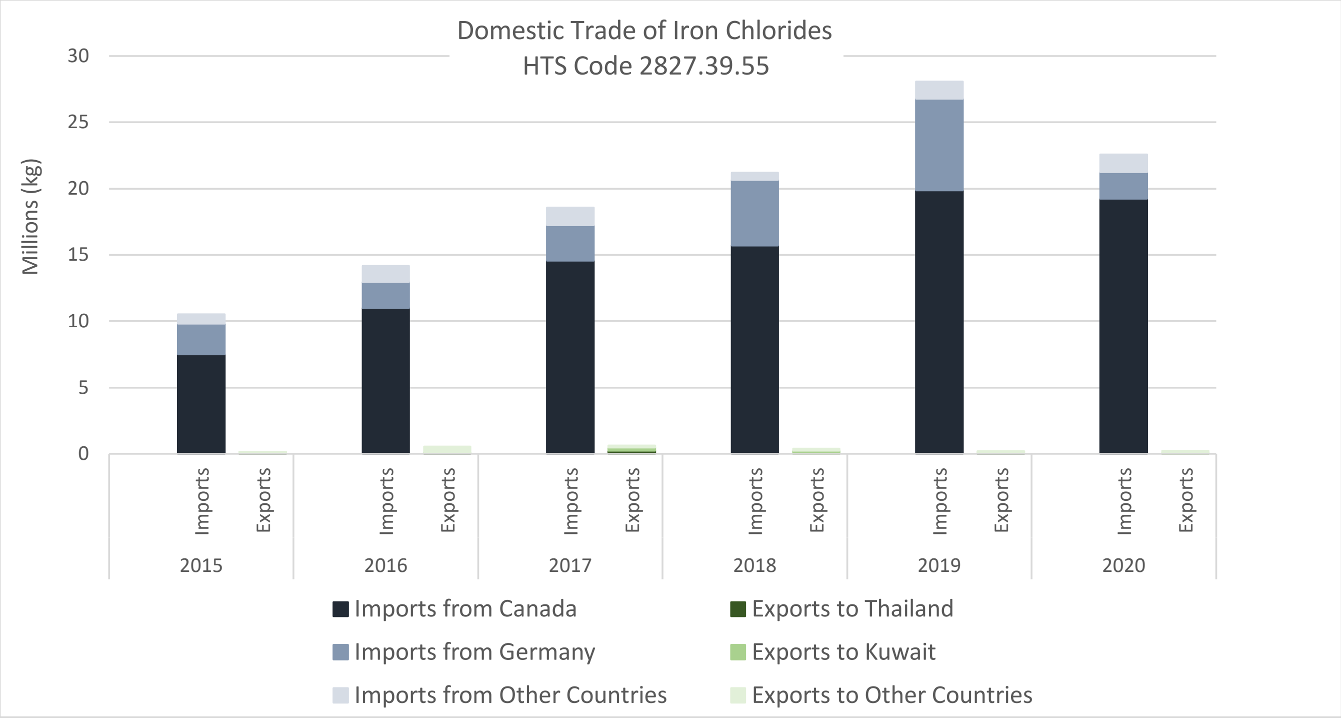


Figure 4. USITC Domestic Import and Export of Iron Chlorides between 2015 and 2020

Tariffs

There is a 3.7% general duty for import ferric chloride and an additional 25% duty on imports from China (USITC, 2022), as summarized in Table 3.

Table 3. 2021 Domestic Tariff Schedule for Iron Chlorides

HTS Number	General Duty	Additional Duty – China (Section 301 Tariff List)	Special Duty
2827.39.55	3.7%	25%	Free for A, AU, BH, CA, CL, CO, D, E, IL, JO, KR, MA, MX, OM, P, PA, PE, SG[3]

Market History & Risk Assessment

History of Shortages

The production of ferric chloride in North America is heavily reliant on the steel industry for the precursor, ferrous chloride, and the chlor-alkali industry for chlorine and hydrochloric acid. Economic slowdowns and a drop in domestic steel manufacturing along with greater recycling of steel pickling liquor and fluctuating prices for hydrochloric acid have been known to impact the availability of ferrous chloride and have led to price fluctuations for ferric chloride.

In the fall of 2020 and continuing through 2021, there were disruptions in the supply of chlorine and hydrochloric acid. Concurrently, there was also a contraction in domestic steel production, which reduced availability of spent steel pickling liquors. Discussion with industry representatives indicated that challenges in obtaining ferric chloride were primarily due to a shortage of hydrochloric acid and spent pickling liquor. In

[3] Symbols used to designate the various preference programs and trade agreements. A full list of special trade agreements and associated acronyms can be found at https://help.cbp.gov/s/article/Article-310?language=en_US and the General Notes Section of the Harmonized Tariff Schedule https://hts.usitc.gov/current

addition to the shortage of precursors, there was also a series of equipment failures at a major ferric chloride production facility, and due to the specialized nature of the equipment, it took months to complete the repairs and restore facility operations. There were also reports of truck and driver shortages impacting all parts of the supply chain.

Risk Evaluation

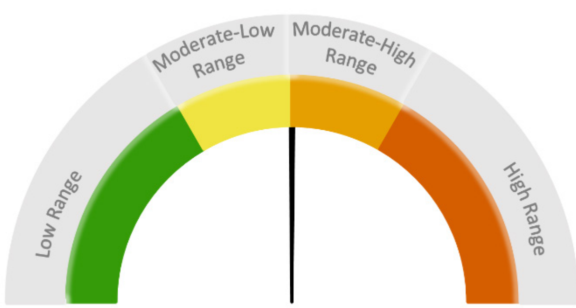
The complete risk evaluation methodology is described in *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions* (EPA, 2022c). The risk rating is calculated as the product of the following three risk parameters:

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 Chloride

Risk Parameter Ratings and Drivers		
Criticality High	**Likelihood High**	**Vulnerability Low**
Ferric chloride is an essential water treatment chemical. It is widely used as a coagulant and sludge dewatering agent.	The water sector has experienced regional ferric chloride supply disruptions and significant price fluctuations in the past. Lack of supply of key inputs (steel pickling liquor, chlorine, and hydrochloric acid) contributed to a shortage in 2021.	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 increases vulnerability.
Risk Rating: Moderate-Low		



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