Ferrous Chloride

$FeCl_2$

Direct Use Chemical | Precursor Chemical

(liquid, solid)

Inputs to Manufacturing Process:
- Hydrochloric Acid
- Iron Oxides
- Iron

% of Total Domestic Consumption Attributed to Water Sector:
Greater than 10%

Product Family:
Chlor-alkali
Iron

Derivative Water Treatment Chemicals:
Ferric Chloride

Understanding Chemical Supply Chains

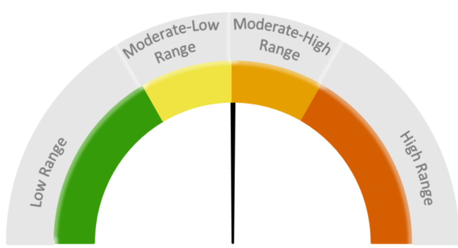
Map of Suppliers & Manufacturers

CAS No.: 7758-94-3

Shelf Life: 12+ Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Moderate-Low



RISK DRIVERS

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

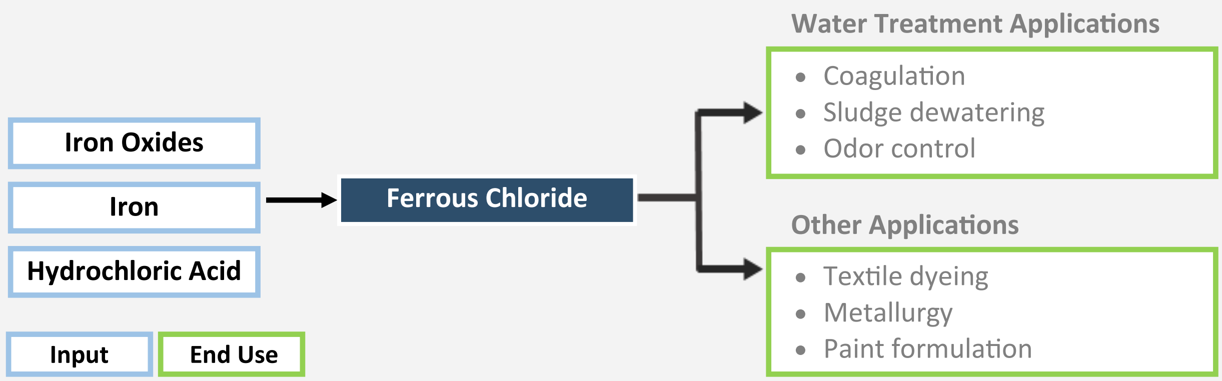
RISK PARAMETERS

Criticality: High. Essential for coagulation and dewatering.

Likelihood: High. Previous regional disruptions in supply and significant price fluctuations that impacted the water sector.

Vulnerability: Low. Distributed domestic manufacturing and supply.

MANUFACTURING PROCESS



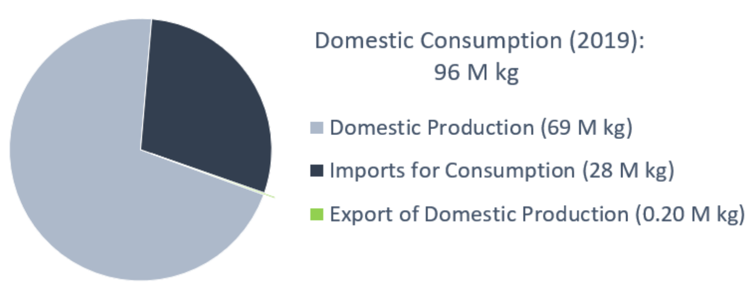
DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

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

International Trade (2019)

Primary Trading Partner (Imports): Canada

Primary Trading Partner (Exports): Thailand



Product Description

Ferrous chloride ($FeCl_2$), an inorganic iron salt, is a widely used coagulant, dewatering agent, and odor control agent. It is primarily produced as a byproduct of steel pickling, a process that relies on iron oxides and hydrochloric acid. Water treatment applications are the primary commercial use of ferrous chloride in the U.S.

Use in Water Treatment

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

Use as a Precursor to Other Water Treatment Chemicals

Ferrous chloride is used to manufacture ferric chloride.

Other Applications

Ferrous chloride is used for textile dyeing, metallurgy, paint formulation, and as a chemical intermediate (NCBI, 2021).

Primary Industrial Consumers

Ferrous chloride is primarily used for wastewater treatment.

Manufacturing, Transport, & Storage

Manufacturing Process

Iron, iron oxides, and hydrochloric acid are the primary materials used to produce ferrous chloride. The method most commonly used in North America utilizes a reaction of spent steel pickling liquors or scrap iron with hydrochloric acid. Pickling of steel removes the surface iron oxide from steel by immersion in a bath containing either a sulfuric or hydrochloric acid solution. When hydrochloric acid is used, mixed oxides in the oxidation layer of the steel as well as the underlying iron react with the hydrochloric acid to form ferrous chloride as shown in Figure 1. Ferrous chloride is then filtered and crystallized (Alcaraz et al., 2021; Michigan DEQ, 2015; Özdemir, et. al, 2006).

Reaction of Mixed Iron Oxides (Fe_2O_3, Fe_3O_4, and FeO) and Steel with Hydrochloric Acid

Iron Oxide + Steel + Hydrochloric Acid → Ferrous Chloride + Water

$$Fe_2O_3 + Fe + 6HCl \rightarrow 3FeCl_2 + 3H_2O$$

Iron Oxide + Steel + Hydrochloric Acid → Ferrous Chloride + Water

$$Fe_3O_4 + Fe + 8HCl \rightarrow 4FeCl_2 + 4H_2O$$

Iron Oxide + Hydrochloric Acid → Ferrous Chloride + Water

$$FeO + 2HCl \rightarrow FeCl_2 + H_2O$$

Iron + Hydrochloric Acid → Ferrous Chloride + Hydrogen

$$Fe + 2HCl \rightarrow FeCl_2 + H_2$$

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

Product Transport

Ferrous chloride may be transported in bulk or container by truck, rail, barge, and ship (Kemira, 2010; SafeRack, 2022).

Storage and Shelf Life

Ferrous chloride is corrosive, and should be stored in corrosion-resistant container. Ferrous chloride should be kept in a cool, dry area. When stored properly, ferrous chloride can have a shelf life in excess of 12 months (Kemira, 2010; Poly Processing, 2017).

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

Table 1. Ferrous Chloride Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source**	**Identifier**	**Description**
Domestic Production	2020 TSCA Chemical Data Reporting	CAS No.: 7758-94-3	Ferrous Chloride
Imports and Exports	U.S. International Trade Commission	HTS Code: 827.39.55	Iron Chlorides, including Ferrous Chloride

Total U.S. domestic manufacturing of ferrous chloride reported under the CDR was approximately 96 million kilograms (M kg) in 2019 (EPA, 2020). Domestic commercial manufacture of ferrous chloride takes place at a limited number of facilities throughout the contiguous U.S. Primary producers include *NMLK Group* (steel manufacturer) and *Phibro-Tech* (iron manufacturer and recycler). Most ferrous chloride production facilities rely on the availability of hydrochloric acid are associated with the steel industry. 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 ferrous chloride for use in drinking water treatment is 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, 2022a).

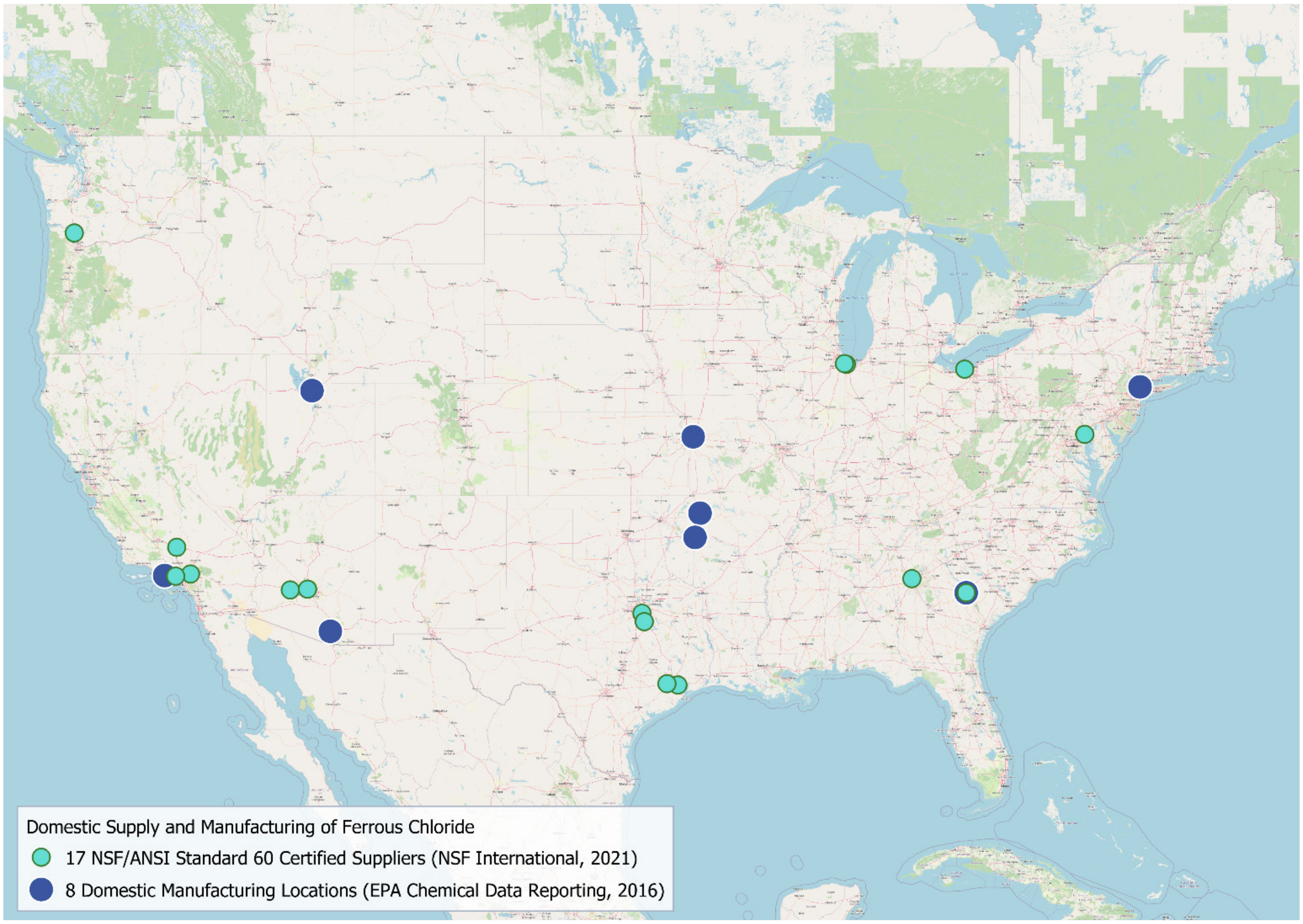


Figure 2. Domestic Supply and Manufacturing of Ferrous Chloride

Domestic Consumption

U.S. consumption of ferrous chloride in 2019 is an estimate based on production of ferrous chloride and trade of a broader category of iron chlorides. Trade of ferrous chloride is an unknown percentage of import and export volume in this category. This estimate includes production of 96 M kg, import of 28 M kg, minus export of 0.20 M kg (EPA, 2020; USITC, 2021), as shown in Figure 3.

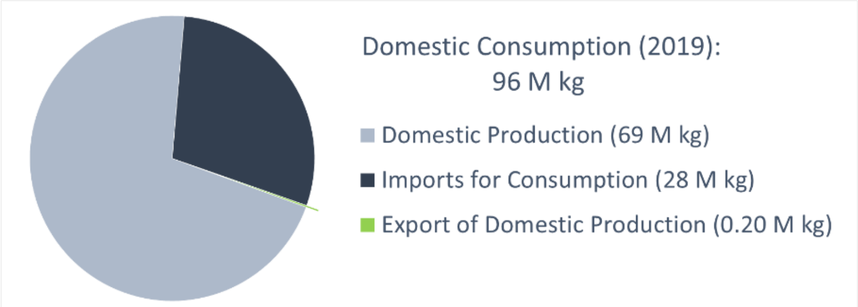


Figure 3. Domestic Production and Consumption of Ferrous Chloride in 2019

Trade & Tariffs

Worldwide Trade

Worldwide import and export data for ferrous 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 ferrous chloride are unavailable from the referenced sources.

Table 2. WITS Worldwide Export and Import of Metal Chlorides, Including Ferrous 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.

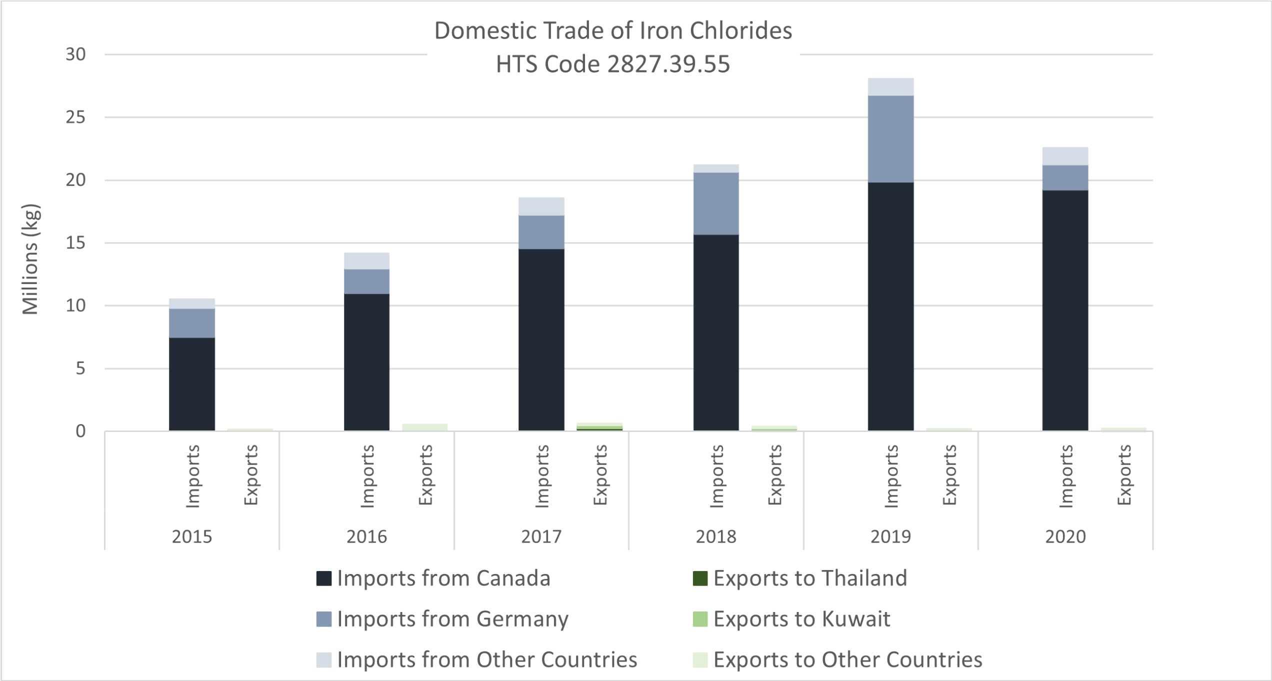


Figure 4. USITC Domestic Import and Export of Iron Chlorides between 2015 and 2020

Tariffs

There is a 3.7% general duty for import ferrous 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 Evaluation

History of Shortages

The production of ferrous chloride in North America is heavily reliant on the steel industry and availability of 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.

Risk Evaluation

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

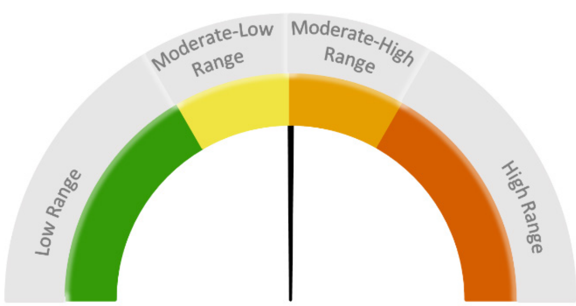
[3] Symbols used to designate the various preference programs and trade agreements. A full list of special trade agreements and associated acronyms can be found at https://help.cbp.gov/s/article/Article-310?language=en_US and the General Notes Section of the Harmonized Tariff Schedule https://hts.usitc.gov/current

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 Ferrous Chloride

Risk Parameter Ratings and Drivers		
Criticality — High	**Likelihood — High**	**Vulnerability — Low**
Ferrous chloride is an essential water treatment chemical. It is widely used as a coagulant and sludge dewatering agent.	The water sector has experienced regional ferrous chloride supply disruptions and significant price fluctuations in the past. Lack of supply of key inputs (steel pickling liquor and 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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