5. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

5.1 PRODUCTION

Boron is the 51st most common element found in the earth's crust and is found at an average concentration of 8 mg/kg (Cotton et al. 1999; Jansen 2003). Boron is a nonmetal and is typically found in nature bound to oxygen. It is never found as the free element (Cotton et al. 1999). There are over 200 minerals containing boron oxide; however, only four boron-containing minerals (borax, kernite, colemite, and ulexite) comprise the majority, nearly 90%, of the borates used by industry worldwide. These minerals are extracted mainly from California and Turkey. The majority of domestic boron production is from Kern County, California, with the remainder from San Bernardino and Inyo Counties in California (USGS 2008).

The most widely used commercial process for producing boron is the Moissan process, which involves the reduction of boric oxide with magnesium (Jansen 2003). This process yields 90–92% pure boron, which is then leached with acid to separate it from the magnesium oxide formed during the process, followed by multiple washes and drying. The purity of the boron can be increased to 95–97% by further chemical processing (Jansen 2003). Due to boron's tendency to bind to electron-rich elements (carbon, nitrogen, and oxygen) it can be very difficult to isolate boron in high purity (Cotton et al. 1999). High purity boron (>99.9%) is prepared by the reduction of boron trihalides or by the decomposition of boron triiodide or boron hydrides at high temperatures. Other methods include electrolytic reduction of potassium tetrafluoroborate (KBF_4) in molten potassium chloride-potassium fluoride mixtures. High purity boron can generally only be obtained in kilogram quantities (Cotton et al. 1999).

In 2005, 1.15 million metric tons of boron ore were produced in the United States, with a boron oxide (B_2O_3) content of 612,000 metric tons. Colemanite, kernite, tincal (natural borax), and ulexite were the most common mineral of commercial importance in the United States. Boron compounds and minerals are produced both by surface and underground mining, as well as from brine (USGS 2008).

Boron trifluoride is prepared by the reaction of a boron-containing material and a fluorine-containing substance in the presence of an acid (e.g., borax, fluorspar, and sulfuric acid) (Alam et al. 2003). It can also be produced by the treatment of fluorosulfonic acid with boric acid. Large-scale production of boron trichloride involves the reaction of chlorine with a mixture of borax and crude oil residue heated in a rotary kiln. On a smaller-scale, boron trichloride can be prepared by reacting chlorine and a mixture of boron oxide, petroleum coke, and lampblack (carbon black) in a fluidized bed. Large-scale production of boron tribromide involves reaction of bromine and granulated boron carbide (B_4C) at 850–1,000 °C or by reaction of hydrogen bromide with calcium boride (CaB_6) at high temperatures (Alam et al. 2003).

Tables 5-1 and 5-2 list facilities in each state that manufacture or process boron trifluoride and boron trichloride, respectively, as well as the intended use and the range of maximum amounts of these boron compounds that are stored onsite. In 2006, there were 50 and 19 reporting facilities that produced, processed, or used boron trifluoride and boron trichloride, respectively, in the United States. The data listed in Tables 5-1 and 5-2 are derived from the Toxics Release Inventory (TRI06 2008). Only certain types of facilities were required to report. Therefore, this is not an exhaustive list. Current U.S. manufacturers of boron and selected boron compounds are given in Table 5-3.

5.2 IMPORT/EXPORT

Turkey was a major import source in 2004–2007 for boric acid, supplying 55%, followed by Chile (24%), Bolivia (8%), Peru (5%), and other (8%) (USGS 2009). In 2008, U.S. imports of borax, boric acid, colemanite, and ulexite were $1x10^3$, $65x10^3$, $27x10^3$, and $90x10^3$ metric tons, respectively. In 2008, U.S. exports of boric acid and refined sodium borates were $260x10^3$ and $470x10^3$ metric tons, respectively (USGS 2009).

5.3 USE

In 2008, the estimated use distribution pattern for boron compounds in the United States was 74% for glass and ceramics, 6% for soaps and detergents and bleaches, 3% for agriculture, 3% for enamels and glazes, and 14% remaining for other (USGS 2009). Boric acid is used in cosmetics, pharmaceuticals, and toiletries. It is also used to reduce the flammability of cellulose insulation, cotton batting in mattresses, and wood composites. Boron oxide is incorporated into cellulose materials to inhibit combustion. Borates are used in the manufacture of adhesives and are added to lubricants, brake fluids, metalworking fluids, water treatment chemicals, and fuel additives (USGS 2008).

Pesticide products containing boric acid and its sodium salts (sodium tetraborate decahydrate, sodium tetraborate pentahydrate, anhydrous sodium tetraborate, disodium octaborate tetrahydrate, anhydrous disodium octaborate, and sodium metaborate) are registered in the United States for use as insecticides, fungicides, and herbicides. There are 189 pesticide products registered that contain boric acid or its

Table 5-1. Facilities that Produce, Process, or Use Boron Trifluoride

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AL	4	1,000	99,999	2, 3, 6, 10
AR	3	1,000	99,999	2, 3, 6
DE	2	100,000	999,999	1, 4, 8
FL	3	0	99,999	6, 10
KY	2	10,000	99,999	10, 12
LA	5	0	999,999	2, 3, 10, 11
MD	2	1,000	99,999	6
NJ	2	0	9,999	6
NY	3	1,000	999,999	6
OH	1	10,000	99,999	6
OK	3	10,000	999,999	1, 3, 6
PA	8	0	999,999	6, 7, 9, 10, 12
SC	6	1,000	99,999	2, 3, 6, 12
TN	1	10,000	99,999	10
TX	13	0	999,999	2, 3, 4, 6, 9, 10, 11, 12

[a]Post office state abbreviations used
[b]Amounts on site reported by facilities in each state
[c]Activities/Uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/Distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation Component
9. Article Component
10. Repackaging
11. Chemical Processing Aid
12. Manufacturing Aid
13. Ancillary/Other Uses
14. Process Impurity

Source: TRI07 2009 (Data are from 2007)

Table 5-2. Facilities that Produce, Process, or Use Boron Trichloride

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AZ	1	100	999	11, 12
CA	2	1,000	99,999	1, 2, 3, 4, 9
IN	3	10,000	999,999	6, 7, 10, 11
MA	2	1,000	9,999	2, 3, 6
MI	1	1,000	9,999	10
NM	2	100	9,999	11
NV	1	0	0	0
OH	1	1,000	9,999	6
PA	4	0	99,999	2, 4, 9
SC	2	1,000	9,999	2, 3, 6, 7, 10, 11, 12
WI	2	1,000	99,999	6
WV	1	10,000	99,999	6

[a]Post office state abbreviations used
[b]Amounts on site reported by facilities in each state
[c]Activities/Uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/Distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation Component
9. Article Component
10. Repackaging
11. Chemical Processing Aid
12. Manufacturing Aid
13. Ancillary/Other Uses
14. Process Impurity

Source: TRI07 2009 (Data are from 2007)

Table 5-3. Current U.S. Manufacturers of Boron and Selected Boron Compounds

Company	Location
Boron	
Eagle-Picher Incoroporated, Eagle-Pitcher Boron LLC	Quapaw, Oklahoma
SB Boron Corporation	Franklin Park, Illinois
TETRA Micronutrients	Fairbury, Nebraska
Tronox Incorporated	Henderson, Nevada
Boron oxide	
Johnson Matthey, Inc., Alfa Aesar	Ward Hill, Massachusetts
Boric acid	
InCide® Technologies, Inc.	Phoenix, Arizona
Searles Valley Minerals, Argus-Trona-Westend Complex	Trona, California
Rio Tinto Minerals	Boron, California
Sodium tetraborate pentahydrate (borax pentahydrate)	
Searles Valley Minerals, Argus-Trona-Westend Complex	Westend, California
Rio Tinto Minerals	Boron, California
Sodium tetraborate decahydrate (borax decahydrate)	
Searles Valley Minerals, Argus-Trona-Westend Complex	Westend, California
Rio Tinto Minerals	Boron, California
Sodium tetraborate (Borax)	
Searles Valley Minerals, Argus-Trona-Westend Complex	Trona, California Westend, California
Rio Tinto Minerals	Boron, California
Boron tribromide	
Air Liquide America L.P., Air Liquide Electronics Division	Dallas, Texas
EP Scientific Products, LLC	Miami, Oklahoma
Schumacher	Carlsbad, California
Boron trifluoride dihydrate	
Atotech USA, Inc.	Rock Hill, South Carolina
Boron trichloride	
Tronox Incorporated	Henderson, Nevada

Source: Stanford Research Institute (SRI 2008), except where otherwise noted. SRI reports production of chemicals produced in commercial quantities (defined as exceeding 5,000 pounds or $10,000 in value annually) by the companies listed.

sodium salt as an active ingredient. Boric acid and its sodium salts are used on several agricultural and many non-agricultural sites including residential, commercial, medical, veterinary, industrial, forestry, and food/feed handling areas. Various formulations are available, including liquids, soluble and emulsifiable concentrates, granulars, powders, dusts, pellets, tablets, solids, paste, baits, and crystalline rods (EPA 1993).

Boron halides are important industrial chemicals. Their Lewis acid properties make them useful as catalysts. Boron trichloride is widely used to prepare boron filaments by chemical vapor deposition (CVD). Much of the boron tribromide produced in the United States is used in the manufacture of proprietary pharmaceuticals (Alam et al. 2003).

Boron isotopes have also found several medical and analytical uses. BNCT, a biologically targeted form of radiotherapy, offers the potential use of the non-radioactive, stable ^{10}B isotope for cancer imaging. This technique may allow selective delivery of ^{10}B to tumors and, as a result, better targeted irradiation of the tumor (Schubert and Brotherton 2006; Wittig et al. 2008). The measured ratio of ^{10}B to ^{11}B is frequently used as a hydrologic and geochemical tracer (Chetelat and Gaillardet 2005; Moore et al. 2008). The natural abundance of ^{10}B and ^{11}B is specific to location, making anthropogenic boron isotopic ratios from a mined location distinctly different than that found in most groundwater and soil ratios (Davidson and Bassett 1993). This allows utilization of the boron isotopic ratio to determine potential contamination in groundwater (Vengosh et al. 1994), river water (Chetelat and Gaillardet 2005), marine water (Xiao et al. 2007), and effluent (Kloppmann et al. 2008).

5.4 DISPOSAL

Boron trifluoride and boron trichloride are classified as extremely hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as Superfund, and the Superfund Amendments and Reauthorization Act (SARA) of 1986 and the Emergency Planning and Community Right-to-Know Act (EPCRA), also known as Title III of SARA. Under CERCLA, spills or discharges into the environment of more than 500 pounds of boron trifluoride or boron trichloride must be reported immediately to the National Response Center (EPA 2008b).

Boron trifluoride and boron trichloride are also regulated under the chemical accident prevention provisions of the Clean Air Act (CAA) amendments of 1990. Owners and operators of stationary sources who produce, process, handle, or store boron trifluoride in excess of 5,000 pounds are required to initiate specific activities to prevent and mitigate accidental releases (i.e., hazard assessment, a prevention program, and an emergency response program) (EPA 2008a).

Boron recycling in the United States during 2008 was insignificant (USGS 2009). No other information regarding disposal of boron or other boron compounds was located.