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 2007b).

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 2007b).

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 2005, there were 47 and 16 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 (TRI05 2007). 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 2002–2005 for boric acid, supplying 57%, followed by Chile (31%), Peru (5%), and Russia (3%) (USGS 2007a). In 2005, U.S. imports of borax, boric acid, colemanite, and ulexite were $1x10^3$, $52x10^3$, $31x10^3$, and $103x10^3$ metric tons, respectively. In 2005, U.S. exports of boric acid and refined sodium borates were $183x10^3$ and $308x10^3$ metric tons, respectively (USGS 2007a).

5.3 USE

In 2005, the estimated use distribution pattern for boron compounds in the United States was 70% for glass and ceramics, 5% for soaps and detergents, 4% for fire retardants, and 2% for agriculture, with other uses, including metallurgy, nuclear applications, sale to distributors, and miscellaneous applications, making up the remaining 19% (USGS 2007a). 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 2007b).

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 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,

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	1	100,000	999,999	1, 4
FL	2	10,000	99,999	6, 10
KY	2	10,000	99,999	10, 12
LA	4	1,000	999,999	2, 3, 10, 11
MD	2	1,000	99,999	6
NJ	1	1,000	9,999	6
NY	3	1,000	999,999	6
OH	1	10,000	99,999	6
OK	2	10,000	999,999	1, 3, 6
PA	7	1,000	999,999	6, 7, 9, 10, 12
SC	4	1,000	99,999	2, 3, 6
TN	1	10,000	99,999	10
TX	10	1,000	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: TRI05 2007 (Data are from 2005)

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	1	1,000	9,999	1, 3, 4, 9
IN	3	10,000	999,999	6, 7, 10, 11
MA	1	1,000	9,999	6
MI	1	1,000	9,999	10
NM	2	100	9,999	11
OH	1	1,000	9,999	6
PA	3	1,000	99,999	2, 4, 9
SC	1	1,000	9,999	2, 3, 6, 7, 10, 11
WI	2	1,000	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: TRI05 2007 (Data are from 2005)

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

Company	Location
Boron	
Eagle-Picher Industries, Inc., Eagle-Pitcher Technologies, LLC, Boron Department	Quapaw, Oklahoma
SB Boron Corporation	Franklin Park, Illinois
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
U.S. Borax Inc.	Boron, California
Sodium tetraborate decahydrate (Borax decahydrate)	
Searles Valley Minerals, Argus-Trona-Westend Complex	Westend, California
U.S. Borax Inc.	Boron, California
Sodium tetraborate (Borax)	
Searles Valley Minerals, Argus-Trona-Westend Complex	Trona, California Westend, California
U.S. Borax Inc.	Boron, California
Boron tribromide	
Air Liquide America L.P., Air Liquide Electronics Division	Dallas, Texas
Eagle-Picher Industries, Inc., Eagle-Pitcher Technologies, LLC, Environmental Science and Technology Department	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 2006), 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.

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).

5.4 DISPOSAL

Boron trifluoride and boron trichloride are classified as an 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 2007c).

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 2007b).

Boron recycling in the United States during 2005 was insignificant (USGS 2007a). No other information regarding disposal of boron or other boron compounds was located.