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

5.1 PRODUCTION

Ammonia is both a natural and a manufactured chemical. It is a key intermediate in the nitrogen cycle in nature, and microbial production is a major source of ammonia in the world. Recent reports, however, have emphasized the significant influence that humans are having on the global nitrogen budget. At the beginning of the 20th century, most nitrogen was fixed into usable forms (e.g., NH_3) by lightning strikes and microbial nitrogen fixation, with an estimated 90–130 million metric tons (TG) fixed per year. Human production of fixed nitrogen (NH_3) is now estimated to be 140 TG N per year, an amount that is similar to non-anthropogenic sources (NSF 1999; Socolow 1999). The total annual commercial production of ammonia was estimated to result in atmospheric emission of ammonia representing approximately 1–5% of nature's global ammonia emission budget (ApSimon et al. 1987; Buijsman et al. 1987; Crutzen 1983; Galbally 1985; Rosswall 1981).

The largest amount of naturally produced ammonia is thought to arise from soil. Ammonia from decomposing animal excreta probably accounts for the largest proportion of the ammonia produced, with the decay of organic materials from plants, dead animals, and the like contributing significant amounts (Crutzen 1983; Dawson 1977; Dawson and Farmer 1984; Galbally 1985; Irwin and Williams 1988).

Manufacture of ammonia within the United States has declined over the past several years. The U.S. annual commercial production capacity for ammonia was 16.6 million metric tons in 1999 (CMR 1999), 15.7 metric tons in 2000 (SRI 2000), but only 9.5 million metric tons in 2001 (Kramer 2002). High natural gas costs, along with weather-related decreases in demands, contributed to the lower production output. These resulted in almost 40% of production capacity being stopped (Kramer 2002). In 1999, four plant closings eliminated a combined production capacity of 1.2 million tons, some of which was replaced by new facilities (CMR 1999). In 2000, an additional seven plants were completely shut down, and five plants were partially closed due to market conditions (Kramer 2000).

While production decreased over these years and while ammonia plants were closed, the states and companies producing ammonia remained relatively constant. In both 2000 and 2001, Louisiana, Oklahoma, and Texas were the three major producing states, contributing over 55% of the U.S. ammonia production. Six companies (Farmland Industries Inc., Terra Industries Inc., PCS Nitrogen Inc., Agrium

Inc., CF Industries Inc., and Mississippi Chemical Corporation) produced 73% of the nation's ammonia (Kramer 2000).

There are 2,506 facilities that manufacture or process ammonia in the United States (Table 5-1). The amounts manufactured or processed range from 0–99,999 pounds in Hawaii to very large formulation and processing activities (0–499,999,999 pounds) in Alaska, Alabama, Georgia, Iowa, Louisiana, Nebraska, and Texas. As mentioned previously, three states, Louisiana, Oklahoma, and Texas, produce more than 55% of the nation's total NH_3 output.

The major method for commercial production of anhydrous ammonia is a modified Haber-Bosch process. This process was first demonstrated in 1909 (Kramer 2000), and was commercially developed in 1913 in Germany. The first U.S. plant to use this process was built in Syracuse, New York, in 1921 (DOI 1985). The basic Haber-Bosch methodology was still responsible for 98% of the industrially produced ammonia in the United States in 1979 (EPA 1980; HSDB 2002). In this process, nitrogen (obtained from the atmosphere) and hydrogen (obtained from natural gas) are mixed together in a 1 to 3 ratio and passed over a catalyst at high pressure. The ammonia thus produced is collected by various means, and any unreacted feed gases are recirculated through the reactor.

Small amounts of ammonia are produced industrially as a by product of the coking of coal. The largest proportion of industrial ammonia production occurs in areas where natural gas is cheap and plentiful because ammonia is synthesized using natural gas. Large pipelines stretching from Louisiana to Nebraska and from Texas to Minnesota carry anhydrous ammonia from its site of production to agricultural areas where it is used as fertilizer (LeBlanc et al. 1978). These pipelines are capable of transporting or storing 3 million metric tons of ammonia per year, and have a storage capacity of 1.5 million metric tons (Kramer 2000). Ammonia can also be shipped in large refrigerated, low pressure tanks (holding between 4 and 30 thousand tons) or smaller (holding approximately 210 tons), pressurized tanks (Farm Chemicals Handbook 1987). Barges are often used for refrigerated shipments because of their lower cost. Ammonia can be stored in refrigerated tanks holding up to 36,000 tons for use in the ammonia market. Smaller amounts of ammonia are stored in pressurized tanks.

Historically, domestic production has consistently met the demand, and should remain relatively constant, yet it will depend on the amount of crop acres planted, and the price of imported fertilizers, and the cost of natural gas. Due to the low production yields in 2001, imports increased from 3.88 million

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

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AK	4	1,000	499,999,999	1, 3, 4, 5, 6, 10, 11, 12
AL	70	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13
AR	50	100	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
AS	1	10,000	99,999	11
AZ	21	100	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
CA	183	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
CO	20	0	999,999	1, 5, 6, 7, 9, 11, 12
CT	23	0	999,999	1, 2, 3, 5, 6, 7, 8, 10, 11, 12
DC	2	10,000	99,999	12
DE	15	0	999,999	1, 2, 3, 5, 6, 7, 10, 11, 12
FL	59	100	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
GA	93	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
HI	6	0	99,999	1, 3, 5, 6, 10, 12, 13, 14
IA	62	100	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
ID	22	0	49,999,999	1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 13
IL	111	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
IN	73	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
KS	35	100	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13
KY	39	0	9,999,999	1, 3, 5, 6, 7, 9, 10, 11, 12, 13
LA	79	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13
MA	36	0	999,999	1, 2, 3, 5, 6, 9, 10, 11, 12
MD	18	100	999,999	1, 3, 5, 6, 7, 8, 10, 11, 12, 13, 14
ME	13	0	999,999	1, 2, 3, 5, 6, 10, 11, 12, 13
MI	78	0	999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
MN	41	0	9,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13
MO	50	1,000	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
MS	37	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
MT	14	0	9,999,999	1, 3, 4, 5, 6, 10, 11, 12
NC	82	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
ND	8	0	999,999	1, 2, 5, 10, 11, 12, 13
NE	35	100	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
NH	19	0	9,999,999	1, 3, 4, 5, 6, 7, 10, 11, 12
NJ	62	0	9,999,999	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
NM	6	100	99,999	1, 2, 3, 5, 7, 10, 11, 12
NV	13	1,000	9,999,999	1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 14
NY	70	0	49,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13
OH	129	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
OK	28	0	99,999,999	1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13
OR	45	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
PA	103	0	99,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13
PR	20	100	999,999	1, 2, 3, 4, 5, 6, 7, 9, 10, 12

Table 5-1. Facilities that Produce, Process, or Use Ammonia (*continued*)

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
RI	12	1,000	9,999,999	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12
SC	61	0	999,999	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
SD	4	1,000	999,999	1, 5, 10, 11, 12
TN	56	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
TX	196	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
UT	25	100	9,999,999	1, 3, 5, 6, 7, 9, 10, 11, 12, 13
VA	61	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
VI	1	100,000	999,999	1, 2, 3, 5, 6, 10, 12
VT	2	1,000	9,999	1, 5, 11, 12
WA	42	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

Source: TRI00 2002

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

1. Produce
2. Imported
3. Used Processed
4. Sale Distribution
5. Byproduct
6. Reactant
7. Formulation Component
8. Article Component
9. Repackaging
10. Chemical Processing Aid
11. Manufacture Aid
12. Ancillary/Other Uses
13. Manufacture Impurity
14. Process Impurity

metric tons in 2000 to more than 5 million metric tons in 2001, and reliance on imported ammonia increased from 20 to 29% (Kramer 2002).

5.2 IMPORT/EXPORT

Imports into the United States totaled more than 5 million metric tons in 2001 (Kramer 2002), an increase of 29% from 2000. U.S. exports of ammonia were 6.7 metric tons, which is slightly higher than exports in 2000 (6.62 million metric tons).

5.3 USE

The largest and most significant use of ammonia and ammonium compounds is the agricultural application of fertilizers. Ammonia and ammonium compounds used as fertilizer represent 89% of the commercially produced ammonia, with plastics, synthetic fibers and resins, explosives, and other uses accounting for most of the remainder (Kramer 2002). Direct uses of ammonia as fertilizer can be broken down into the following categories: anhydrous ammonia, 30%; urea/ammonium nitrate solutions, 24%; urea, 17.5%; ammonium nitrate, 5%; ammonium sulfate, 2%; other forms, 2.5%; and multiple nutrient forms, 19% (Kramer 2000). Most ammonium compounds and nitric acid, which are produced from anhydrous ammonia, are used directly in the production of fertilizers.

The small proportion of commercially produced ammonia not incorporated into fertilizers is used as a corrosion inhibitor, in the purification of water supplies, as a component of household cleaners, and as a refrigerant. It is also used in the pulp and paper, metallurgy, rubber, food and beverage, textile, and leather industries. Ammonia is used in the manufacture of pharmaceuticals and explosives, and in the production of various chemical intermediates (LeBlanc et al. 1978; Sax and Lewis 1987).

5.4 DISPOSAL

Solutions of ammonia can be highly diluted with water, or alternatively, diluted with water and neutralized with HCl and then routed to the sewer system. The amount released to the receiving stream should not exceed the established limits for ammonia. Limited amounts of gaseous ammonia may be discharged to the atmosphere. Federal, state, and local guidelines should be consulted before disposal.

Disposal of liquified ammonia or of large quantities of gaseous or aqueous ammonia directly into water is not desirable, because of the large amount of heat generated. This generation of heat could increase exposure to personnel involved in the process. Recovery of ammonia from aqueous waste solutions is a viable option for many industries (HSDB 2002).