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

5.1 PRODUCTION

No information is available in the Toxic Release Inventory (TRI) database on facilities that manufacture or process RDX because this chemical is not required to be reported under Section 313 of the Emergency Planning and Community Right-to-Know Act (Title III of the Superfund Amendments and Reauthorization Act of 1986) (EPA 2010).

RDX is produced by nitrolysis of hexamine with nitric acid (HSDB 2009; Lewis 2007). In the Bachmann process, used in the United States, hexamine is reacted with nitric acid, ammonium nitrate, glacial acetic acid, and acetic anhydride (Boileau et al. 2009; Budavari and O'Neil 1989; HSDB 2009; U.S. Army 1978c, 1986e). The crude product is filtered and recrystallized to form RDX (U.S. Army 1986a). The Woolrich process, typically used in the United Kingdom and France, does not use acetic anhydride. The raw materials consist of hexamine and 98–99% nitric acid; however, this complex exothermic reaction is not completely understood (Boileau et al. 2009).

Another process that has been used to manufacture RDX by the direct nitration of HMX has not yielded a percentage of RDX as high as that produced in the Bachmann process (Budavari and O'Neil 1989; U.S. Army 1978c).

Production of RDX peaked in the 1960s when it was ranked third in explosive production by volume in the United States (U.S. Army 1986e). The average volume of RDX produced from 1969 to 1971 was 15 million pounds per month. However, production of RDX decreased to a yearly total of 16 million pounds for 1984.

RDX is not produced commercially in the United States (HSDB 2009). Current production in the United States is limited to military use at the Holston Army Ammunition Plant in Kingsport, Tennessee (SRI 2009). In the past, several Army ammunition plants, such as Louisiana (Shreveport, Louisiana), Lone Star (Texarkana, Texas), Iowa (Middletown, Iowa), and Milan (Milan, Tennessee), may have also handled and packaged RDX (U.S. Army 1986e). In 1980, RDX was produced at five facilities in the United States, including Borden (Fayetteville, North Carolina), Hooker (North Tonawanda, New York), Plastics Engineering (Sheboygan, Wisconsin), Tenneco (Fords, New Jersey), and Wright Chemical

(Riegelwood, North Carolina). U.S. capacity in 1980 was 119 million pounds per year (CMR 1980). In 2006, 6.9 million pounds were produced at Holston Army Ammunition Plant (EPA 2006c).

5.2 IMPORT/EXPORT

No information is available regarding the import or export of RDX.

5.3 USE

RDX is a nitramine explosive compound (Turley and Brewster 1987) that can be utilized as a propellant, gunpowder, or high explosive depending on the initiation type (Boileau et al. 2009). RDX has both military and civilian applications. As a military explosive, RDX can be used alone as a base charge for detonators or mixed with another explosive such as TNT to form cyclotols, which produce a bursting charge for aerial bombs, mines, and torpedoes (HSDB 2009; Lewis 2000; Sax and Lewis 1989; Stokinger 1982). As an explosive, RDX is one and a half times more powerful than TNT and is easily initiated with mercury fulminate (Lewis 2007). Common military uses of RDX have been as an ingredient in plastic bonded explosives or plastic explosives, which have been used as explosive fill in almost all types of munition compounds (Gibbs and Popolato 1980; HSDB 2009). The plasticized form of RDX, composition C-4, contains 91% RDX, 2.1% polyisobutylene, 1.6% motor oil, and 5.3% 2-ethylhexyl sebacate (Turley and Brewster 1987). Combinations of RDX and HMX, another explosive, have been the chief ingredients in approximately 75 products (U.S. Army 1978c).

5.4 DISPOSAL

Waste water treatment sludges resulting from the manufacture of RDX are classified as hazardous wastes and are subject to EPA regulations (EPA 1990a). For more information on regulations that apply to RDX, see Chapter 8.

Propellants and explosives have been disposed of through burning, decomposition, re-use, and recovery (Bohn et al. 1997). Byproducts of military explosives such as RDX have also been openly burned in many Army ammunition plants in the past. There are indications that, in recent years, as much as 80% of waste munitions and propellants have been disposed of by incineration (U.S. Army 1986a). Wastes containing RDX have been incinerated by grinding the explosive wastes with a flying knife cutter and spraying the ground material with water to form a slurry. The types of incineration used to dispose of waste munitions containing RDX include rotary kiln incineration, fluidized bed incineration, and pyrolytic incineration (U.S. Army 1986a). The primary disadvantage of open burning or incineration is that explosive contaminants are often released into the air, water, and soils (U.S. Army 1986c). Munitions such as RDX have also been disposed of in the past by dumping into deep seawater (Hoffsommer and Rosen 1972).

RDX wastes found in soils and sediments have been degraded in composts using substances such as hay, horse feed, sewage sludge, wood shavings or sawdust, animal manure, and fruit and vegetable wastes (Greist et al. 1993; Gunderson et al. 1997; U.S. Army 1986b; Williams et al. 1992). In a mechanically stirred amended compost, the concentration of RDX in soil was reduced from <800 to 39 mg/kg after 44 days (Griest et al. 1993). RDX in contaminated soil from a dry explosives washout lagoon decreased from 884 to <2.9 mg/kg after 6 months using a 70% organic compost (Gunderson et al. 1997). RDX has been removed from munitions waste waters and contaminated groundwater by activated carbon columns (Bricka and Sharp 1992; U.S. Army 1987c; Wujcik et al. 1992). No RDX was detected when contaminated groundwater containing 487 μg/L of RDX was passed through granular activated carbon (GAC) columns at a loading rate of 7.11 gpm/ft, a flow rate of 0.7 gpm, and an empty-bed contact time of 4.2 minutes (Wujcik et al. 1992). Once carbon columns were saturated with explosive, they were traditionally destroyed by open burning. Since this practice is no longer allowed in many areas, other disposal alternatives for spent carbons, such as thermal reactivation for reuse, oxidative incineration with ash burial, and thermal deactivation with carbon burial, have been investigated (U.S. Army 1987c). In a feasibility study, ultraviolet irradiation was found to provide effective treatment of RDX-contaminated groundwater (Bricka and Sharp 1992).