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

4.1 PRODUCTION

Named after its inventor, Otto Reitlinger (Forman 1988), Otto Fuel II consists of the nitrated ester explosive propellant propylene glycol dinitrate (PGDN), to which a desensitizer (dibutyl sebacate) and a stabilizer (2-nitrodiphenylamine) have been added (Kessick et al. 1978; Rivera 1974). The chief component, propylene glycol dinitrate, accounts for approximately 75% of the mixture, while dibutyl sebacate and 2-nitrodiphenylamine account for approximately 23% and 2%, respectively (Air Force 1985a; Kessick et al. 1978). Wilshire Chemical Co., Inc., of Gardena, California, is the only manufacturer or distributor of propylene glycol dinitrate that was located, and production volumes for this facility were not available (Van and Deyrup 1991). Information on the manufacture of Otto Fuel II was not located. Since Otto Fuel II releases are not required to be reported under SARA Section 313, there are no data on Otto Fuel II in the 1994 Toxic Release Inventory.

2-Nitrodiphenylamine is produced by the reaction of 2-chloronitrobenzene and aniline in the presence of sodium carbonate (Army 1979). A yield of 96% is obtained by removing water in the form of its aniline azeotrope. As of 1978, the only U.S. manufacturer was American Cyanamid Company. There were at least four foreign manufacturers, including Bayer AG in Germany, as well as Hickson & Welch Ltd., Hopkin & Williams, and Koch-Light Laboratories Ltd. in the United Kingdom. Radford Army Ammunition Plant was the only Army ammunition plant employing 2-nitrodiphenylamine at that time. Current domestic producers of 2nitrodiphenylamine include the Aceto Corporation of Lake Success, New York, and Schweizerhall, Inc., of Piscataway, New Jersey (Van and Deyrup 1991). Production volume data, including data on the amounts used by the US. Navy in Otto Fuel II, were not located.

Dibutyl sebacate can be synthesized by at least three methods: (1) reaction of sebacic acid and butanol in the presence of an appropriate esterification catalyst; (2) distillation of sebacic acid with butyl alcohol in the presence of concentrated hydrochloric acid in a benzene solution; and (3) reaction of butyl alcohol with sebacyl chloride (HSDB 1994). Current manufacturers of dibutyl sebacate and their production sites include Eastech Chemical Inc., Philadelphia, Pennsylvania; Merrand International Corporation, Stow, Ohio; Ivanhoe Industries, Inc., Pennington, New Jersey; Bayer USA Inc., Carteret, New Jersey; Union Camp Corp., Chicago, Illinois; The C.P. Hall Company, Dover, Ohio; and Hatco

Chemical Corporation, Fords, New Jersey (SRI 1991; Thomas Publishing 1990a; Van and Deyrup 1991). U.S. production volumes in 1972 totaled 2.04 million kilograms. The volume increased slightly to 2.54 million kilograms by 1975, although this included 2-ethylhexyl sebacate as well (HSDB 1994). More current production data could not be located.

4.2 IMPORT/EXPORT

Import and export data for Otto Fuel II and its three components could not be located.

4.3 USE

Otto Fuel II is a liquid monopropellant (it does not require an atmosphere containing oxygen to support combustion) used by the U.S. Navy in MK-46 and MK-48 torpedoes (Rivera 1974) and other weapons systems (Air Force 1985a).

The principal current use of propylene glycol dinitrate is as a propellant in Otto Fuel II (Forman 1988). Nitrates of polyhydric alcohols, of which propylene glycol dinitrate is an example, have been used in medicine for the treatment of angina pectoris, and as explosives since the mid-nineteenth century (Litchfield 1971).

In addition to its use by the U.S. Navy as a stabilizer in the manufacture of Otto Fuel II, 2-nitrodiphenylamine is employed for similar purposes by the U.S. Army in the manufacture of double base solid propellants (Army 1979). It also has civilian applications as a solvent dye (Army 1979; Baughman and Perenich 1988).

Dibutyl sebacate is a desensitizer in Otto Fuel II. However, its major use is as a plasticizer for cellulose acetate butyrate plastics, cellulose acetate propionate plastics, polyvinyl butyral plastics, polystyrene, and many synthetic rubbers (HSDB 1994). Many of the plastic products containing dibutyl sebacate are used in the food packaging industry. Dibutyl sebacate is also used as a lubricating ingredient in shaving lotions, and as a synthetic flavoring additive in non-alcoholic beverages, ice cream, ices, candy, and baked goods.

4.4 DISPOSAL

The available information on the disposal of Otto Fuel II and propylene glycol dinitrate is limited. Most of the available information comes from laboratory-scale and pilot pl,ant studies of potential treatment methods conducted in the 1970s and early 1980s. Biodegradation studies have provided conflicting evidence of the biodegradability of propylene glycol dinitrate (the major component of Otto Fuel II) by conventional sewage treatment methods (Army l98la, 1981b: Kessick et al. 1978; Wyman et al. 1984). Suggested alternative treatment methods have included carbon absorption techniques combined with base hydrolysis of propylene glycol dinitrate to the biodegradable propylene glycol (Kessick et al. 1978), and decomposition of propylene glycol dinitrate using sodium sulfide (Smith et al. 1983). Bench-scale wet air oxidation screening tests conducted at 280 °C for 60 minutes indicate excellent removal of propylene glycol dinitrate from waste streams that are too dilute to incinerate and too toxic to biotreat (Dietrich et al. 1985).

2-Nitrodiphenylamine is only sparingly soluble in water, and thus it can be recovered as a solid in effluent stream filters (Army 1979). At the Radford Army Ammunition Plant in Radford, Virginia, it was estimated that one-half to two-thirds of the 2-nitrodiphenylamine that is lost during preparation and processing operations is recovered in this manner.

No information on the disposal or treatment of dibutyl sebacate was located.