4. PRODUCTION, IMPORT, USE, AND DISPOSAL

4.1 PRODUCTION

The principal source of thorium is monazite (phosphate of rare earth metals, usually with thorium), a mineral produced as a by-product of mineral sands mined for titanium and zirconium. Thorium compounds are extracted from monazite by acid and alkali treatment processes (Hedrick 1985). Associated Minerals, a subsidiary of the Australian-owned firm Associated Minerals Consolidated Ltd., was the only commercial operation in the United States to produce purified monazite in 1987. This company produced monazite as a by-product of mineral sands mined for titanium and zirconium minerals at Green Cove Springs, FL. The monazite produced in the United States was exported. Thorium products used domestically were obtained from imported material, existing company stocks, and thorium nitrate previously released from the National Defense Stockpile (Hedrick 1987). In 1984, the mine production capacity for thorium in the United States was 20 metric tons of thorium oxide equivalent (Hedrick 1985). Actual mine production data have not been released over the years to avoid disclosure of proprietary information. Nevertheless, the domestic mine production volume of monazite or other thorium ore is expected to be approximately the same as the United States export volume. The principal processors of thorium-containing ores in the United States during 1987 were W.R Grace & Co. in Chattanooga, TN, and Rhone-Poulenc Inc. in Freeport, TX (Hedrick 1987). United States companies that have thorium processing and fabricating capacities are listed in Table 4-1.

4.2 IMPORT

Imports of thorium into the United States in metric tons of thorium oxide equivalent were 45.8 in 1983, 45.4 in 1984, 69.3 in 1985, 19.7 in 1986, and 30.7 in 1987. Additionally, concentrated monazite containing 350-550 tons of $Th0_2$ has been imported annually (Hedrick 1987). Imports of thorium by the United States may decrease as a result of increased costs of processing thorium. These increased costs are primarily due to increasing concerns about the radiological risks of handling, storing, and disposing of thorium, thereby encouraging the search for nonradioactive substitutes (Hedrick 1987). Exports of thorium metal, waste, and scrap from the United States in metric tons of thorium oxide equivalent were 1.1 in 1983, 1.0 in 1984, 1.6 in 1985, 17.0 in 1986, and 20.4 in 1987 (Hedrick 1987).

4.3 USE

Thorium can be used as fuel in the generation of nuclear energy. However, there is currently only one plant in the United States that is using thorium for the production of energy (Hedrick 1987). In 1983, 3 metric tons of thorium oxide equivalent were used for energy uses in the United States (Hedrick 1985). Nonenergy uses accounted for almost all of the thorium used in the United States during 1987. The 1987 use pattern for thorium was as follows: refractory applications (57%); lamp mantles (18%); aerospace alloys (15%); welding electrodes (5%); nuclear weapon

TABLE 4-1. United States Companies with Thorium Processing and Fabricating Capacity[a]

Company	Plant Location	Operations and Products
Atomergic Chemetals Corp.	Plainview, NY	Produces oxide, flouride, metal
Bettis Atomic Power Laboratory	West Mifflin, PA	Nuclear fuels; Government Research and development
Cerac Inc.	Milwaukee, WI	Produces ceramics
Ceradyne Inc.	Santa Ana, CA	Produces advanced technical ceramics
Chicago Magnesium Castings Co.	Blue Island, IL	Magnesium-thorium alloys
Coleman Co. Inc.	Wichita KS	Produces thoriated mantles
GA Technologies Inc.	San Diego, CA	Nuclear fuels
W.R. Grace & Co., Davison Chemical Div.	Chattanooga, TN	Produces thorium from compounds in monazite
GTE Sylvania	Towanda, PA	Produces thoriated welding rods
Hitchcock Industries Inc.	South Bloomington, MN	Magnesium-thorium alloys
Philips Elmet	Lewiston, ME	Produces thoriated welding rods
Rhône-Poulenc Inc.	Freeport, TX	Produces thorium nitrate from an intermediate compound of monazite
Spectrulite Consortium Inc	Madison, IL	Magnesium-thorium alloys
Teledyne Cast products	Pomona, CA	Magnesium-thorium alloys
Teledyne Wah Chang	Huntsville, AL	Produces thoriated welding rods
Union Carbide Corp., Nuclear Div.	Oak Ridge, TN	Nuclear fuels; test quantities
Wellman Dynamics Corp.	Creston, IA	Magnesium-thorium alloys
Westinghouse Materials Co. of Ohio[b]	Cincinnati, OH	Produces compounds and metals; manages DOE thorium stocks

[a]Source: Hedrick 1987.
[b]Manager of U.S. Department of Energy stocks; formerly NLO Inc., prior to January 1, 1986.

production; and other applications including ceramics and special use lighting (5%). Specific applications include production of investment molds for casting high-temperature metals and alloys, crucibles and alloys of special shapes for use in high-temperature vacuum or oxidizing furnaces. Other special applications include production of core-retention beds used in nuclear reactors to contain and possibly diffuse heat generated by accidental core meltdown; magnesium-thorium alloys for strategic aircraft such as military jet fighters and bombers; mantles for incandescent lanterns such as those used on camping trips; thoriated tungsten electrodes used to join stainless steels and other alloys which require controlled weld applications; special lighting such as airport runway lighting; computer memory components; photoconductive film; and target material for x-rays (Hedrick 1985). Natural thorium is also used in ceramic tableware glaze and in flints for lighters (UNSCEAR 1977). Domestic nonenergy thorium consumption was estimated to be 39.4 metric tons of thorium oxide equivalent in 1987, a decrease of 33 metric tons from 1986 usage. The drop in consumption was primarily the result of reduced demand for thorium oxide in high-temperature refractory molds, because suitable substitutes had been developed (Hedrick 1987).

4.4 DISPOSAL

Disposal of radioactive wastes is a serious environmental problem for which there is, as yet, no completely satisfactory solution. Intensive research is being conducted by both government and industry for the disposal of this type of waste. Small amounts of low-level wastes containing radioisotopes can be diluted with an inert material sufficiently to reduce its activity to an acceptable level for further storage or disposal. At one nuclear waste disposal site, high-level reactor wastes are stored in concrete tanks lined with steel which are buried under a foot of concrete and 5-6 feet of soil. Use of compressed alumina (corundum) containers has been recommended, since this material remains impervious to water indefinitely. The Department of Energy has recommended disposal in deep geologic formations. Disposal in salt formations is being considered since they are self-sealing and free from water (Hawley 1981). The Department of Defense Authorization Act, 1987 (Public Law 99-661) authorized 4536 kg (10,000 pounds) of thorium nitrate for disposal in fiscal year 1987. Further information regarding the amount of thorium disposed of in the United States was not located. Regulations established by the Environmental Protection Agency regarding release limits which apply to the storage and disposal of spent nuclear fuel, high-level radioactive wastes, and transuranic radioactive wastes can be found in 40 CFR 191 and 40 CFR 192.