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

5.1 PRODUCTION

Synthetic vitreous fibers are unlike common minerals because they are amorphous and do not occur naturally in the environment. Fibrous glass and glass wool are made by melting sand in combination with other oxides such as lime or soda without crystallizing them. Rock wool is derived from igneous rock containing high levels of calcium, while slag wool is produced from the by-products of metal smelting. Although rock wool and slag wool were being produced in Europe in the mid to late 19th century, it was not until after World War I that its production within the United States became significant (IARC 1988). In 1928, there were 8 manufacturing plants in the United States that produced rock wool or slag wool, by 1939, the number had grown to 25, and in 1985, there were 58 facilities in the United States producing fibrous glass, mineral wool, and refractory ceramics (IARC 1988).

Historical U.S. production volumes for synthetic vitreous fibers are shown in Tables 5-1 and 5-2. Glass wool products comprise the vast majority of synthetic vitreous fibers produced in the United States. The Glass Manufacturing Industry Council (GMIC) reports that there are currently 10 major manufacturers operating about 40 plants around the United States, and estimates that the current production volume of glass fibers, including glass wool, is about 3 million tons ($2.72x10^9$ kg) annually (GMIC 2002). The annual U.S. production of mineral wool is roughly 550,250 tons ($5.0x10^8$ kg), and accounts for approximately 10–15% of the total amount of synthetic vitreous fibers produced. The total domestic production of refractory ceramic fibers was approximately 107.7 million pounds ($4.9x10^7$ kg) in 1997 (Mast et al. 2000). For comparison, the total production volume of all synthetic vitreous fibers in Canada was estimated as 250–300 kilotons ($2.26x10^8$–$2.71x10^8$ kg) in 1991, of which 70% was glass wool, 20% was mineral wool, 10% was continuous filament glass, and <1% was refractory ceramic fibers (Environment Canada 1993).

The production of fibrous glass differs depending upon whether the final product being formed is continuous filament glass fibers or glass wool. In general, a glass-making furnace is used to melt the raw materials and a separate device is frequently used to convert the melt into marbles. The preformed marbles can be stored, distributed, and remelted for fiber formation. A direct melt process is also

Table 5-1. Production Volumes of Glass Wool, Rock Wool, and Slag Wool Products in the United States[a]

Product	Quantity (million kg), 1977	Quantity (million kg), 1982
Wool for insulation (homes and commercial/industrial buildings)		
Loose and granulated fiber	373.2	327.2
Building batts, blankets, and rolls	359.9 (R-19 or more)[b]	530.0 (R-19 or more)[b]
	403.9 (R-11 to R-18.9)	418.4 (R-11 to R-18.9)
	Not available (R-10.9 or less)	52.3 (R-10.9 or less)
Acoustical, such as wall and ceiling	Not available	46.3
Wool for industrial, equipment, and appliance insulation[c]		
Flexible blankets, rolls, and batts (plain)	167.8	173.2
Flexible blankets, rolls, and batts (coated)	16.5	21.4
Flexible blankets, rolls, and batts (faced)	24.0	Not available
Special purpose insulation	19.6	11.5
Blocks and boards	46.0	10.0
Pipe insulation	30.5	26.8
Acoustical, including pads, boards, and patches	24	Not available

[a]IARC 1988
[b]The R-value is the reciprocal of the amount of heat energy per area of material per degree difference between the outside and inside.
[c]Includes amounts from products produced in the same establishment as well as products purchased or transferred from other establishments.

Table 5-2. Continuous Filament Glass Fiber Production in the United States[a]

Year	Quantity (million kg)
1975	247.88
1976	306.90
1977	357.30
1978	419.04
1979	460.36
1980	393.62
1981	472.61
1982	408.15
1983	530.27
1984	632.88

[a]IARC 1988

employed, which produces the fibers while avoiding the conversion of the melt into marbles. In the production of continuous filament fibers, nozzles are attached to the bushings on the furnace forehearth, and mechanical drawing is used to form the fibers from the melt. A fine mist of water is sprayed onto the strands as they are extruded through the bushing and a lubricating agent is applied before the strands are wound into a cake (IARC 1988).

Glass wool and mineral wool are manufactured with a rotary or centrifugal process without the use of nozzle extruders. In this process, the molten material from the furnace is transferred into a rotating spinner, and the fibers are produced as centrifugal force extrudes the material through small holes in the side of the spinning device. The final wool fibers are generally shorter and thinner than continuous filament fibers. Sometimes, a blowing process in which the melt is forced through the bushings at the bottom of the crucible by a downward directed stream of gas is used to extrude the fibers (Fitzer et al. 1988). The resultant fiber strands are usually about 3–6 μm in diameter and about 3–10 cm in length (Fitzer et al. 1988). Prior to converting the fibers to final products, binders, sizings, or lubricants are usually added. Binders are phenol-formaldehyde resins that impart structural rigidity to the fiber. Lubricating oils or paraffin oils are added to reduce dust and lint formation of the final product and reduce the amount of airborne fibers during their use. Sizings are added to promote adhesion between fibers and the matrix material in reinforced applications. Several sizings are used, including polyvinyl acetate chrome mixture, polyvinyl acetate silane, and epoxy silane (Navy Environmental Health Center 1997).

Special purpose glass fibers are usually produced with a flame attenuation process, which results in the production of very small diameter fibers. The flame attenuation method of producing fibers is a two-step procedure TIMA 1993). In the first step, the melt is drawn through the bushings of the furnace to produce strands of course fibers. The course fibers are then remelted and attenuated into several finer fibers with a high temperature gas flame, normally impinging at right angles to the primary fiber. Fibers are usually propelled by high velocity gasses through a forming tube, upon which a binder is sprayed, before producing the final wool fiber (TIMA 1993).

Refractory ceramic fibers are produced by blowing and spinning processes similar to those used in the production of wool, but the starting material is kaolin clay rather than rock or slag (IARC 1988). Since refractory fibers are relatively new materials, the exact processes used for producing these individual fibers are often considered proprietary and are not disclosed (Fitzer et al. 1988).

5.2 IMPORT/EXPORT

Data regarding the quantities of manmade glass filaments (including glass wool), mineral wool, and refractory ceramic goods imported and exported to and from the United States from 1998 to 2001 are summarized in Table 5-3 (USDOC 2002).

5.3 USE

Synthetic vitreous fibers are an important substitute for asbestos in a variety of products where thermal, acoustical, and electrical resistance is required. Fibrous glass (including glass wool) accounts for about 80% of the production of synthetic vitreous fibers in the United States (WHO 1988). The majority of this production is in the form of glass wool, which is used for insulation purposes, similar to the mineral wools. Continuous filament fibers are used as reinforcement in plastics and building products, and in industrial fabrics (ACGIH 2001). Mineral wool accounts for about 10–15% of the production of synthetic vitreous fibers in the United States (WHO 1988). Similar to glass wool, the vast majority of rock wool and slag wool is produced for thermal and acoustical insulation applications for construction of homes, buildings, and other structures (IARC 1988). Appliances and plumbing applications also use glass wool and mineral wool for insulation purposes. The end products are usually in the form of bats, boards, blankets, and sheets. Refractory ceramics fibers and special purpose fibers only account for about 2% of all synthetic vitreous fibers produced in the United States (WHO 1988). Refractory ceramic materials are very heat resistant and find use in applications that require high temperatures. Final products are often in the form of blankets, boards, felts, bulk fibers, and paper and textile products (IARC 1988). Refractory ceramic blankets or boards are often used as insulation in ships and in firewalls to contain fires or in catalytic converters in the automobile industry and in aircraft and aerospace engines (IARC 1988). Ceramic blankets and boards are commonly used as linings for furnaces and kilns. Ceramic fiber textile products such as yarns or fabrics find use in flame resistant clothing, curtains, and other materials. Specialty purpose glass fibers are very expensive to manufacture and only find use in high technology applications such as high performance insulation in the aircraft industry and specialty filtration products (WHO 1988).

Table 5-3. U.S. Import/Export Volume of Glass Fibers (Including Glass Wool), Mineral Wool and Refractory Ceramic Goods[a]

Year	Import quantity (kg)	Export quantity (kg)
Glass fibers including glass wool		
1998	73,074,090	119,386,619
1999	96,924,030	112,438,061
2000	103,001,680	119,829,077
2001	93,045,850	122,598,785
Mineral wool		
1998	4,096,373	13,507,235
1999	4,732,083	12,856,177
2000	5,086,956	15,736,857
2001	4,330,133	15,760,666
Refractory ceramic goods		
1998	26,677,254	21,567,397
1999	23,552,712	11,044,364
2000	28,520,534	16,464,014
2001	24,191,899	12,054,960

[a]USDOC 2002

5.4 DISPOSAL

No components in synthetic vitreous fibers are identified by the EPA as hazardous waste in Resource Conservation and Recovery Act (RCRA) (40CFR Part 261), and as such they may be disposed of in landfills; however, state and local regulations may apply. Provided that refractory ceramic fibers and other synthetic vitreous fibers have an average diameter >1 μm, the EPA agrees that these substances would not fall within the fine mineral fibers category under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and, thus, would not be subject to release reporting and liability requirements. Should synthetic vitreous fibers, however, have an average diameter of ≤1 μm, these substances would be considered hazardous substances and, therefore, would be subject to CERCLA requirements (EPA 1995). The U.S. Navy suggest that all synthetic vitreous fiber material be wetted before placing the material in heavy duty plastic bags or other impermeable objects before being discarded at landfills (Navy Environmental Health Center 1997).

Glass and insulating material are often recycled for further use after being removed or discarded. According to the North American Insulation Manufacturers Association (NAIMA), over 18 billion pounds of glass and insulating material have been recycled in North America since 1992 (NAIMA 2002).