3 RCF Production and Potential for Worker Exposure

3.1 Production

RCF production in the United States began in 1942 on an experimental basis, but RCFs were not commercially available until 1953. Sales of RCFs were modest initially, but they began to expand when the material gained acceptance as an economical alternative insulation for high-temperature kilns and furnaces. Commercial production of RCFs first reached significant levels in the 1970s as oil shortages necessitated reductions in energy consumption. The growing demand for RCFs has also been strongly influenced by the recognition of health effects associated with exposure to asbestos-containing materials and the increasingly stringent regulation of these products in the United States and many other countries.

Annual domestic production of RCFs was an estimated 85.7 million lb in 1990; in 1997, production of RCFs in the United States totaled 107.7 million lb annually [RCFC 1998]. Currently, total U.S. production is estimated to be 80 million lb per year, representing about 1% to 2% of the worldwide production of SVFs [RCFC 2004]. RCFs are also produced in Mexico, Canada, Brazil, Venezuela, South Africa, Australia, Japan, China, Korea, Malaysia, Taiwan, and several countries in Europe [RCFC 1996]. In the United States and Puerto Rico, the primary producers of RCFs include A.P. Green Industries (Pryor, OK), Unifrax Corporation (Niagara Falls, NY, formerly Carborundum), Thermal Ceramics (Augusta, GA), and Vesuvius (King of Prussia, PA, formerly Premier Refractories and Chemicals). The latter three producers account for an estimated 90% of domestic production and are members of the RCFC, which has been active in monitoring exposures, developing product stewardship programs, and funding research to study RCF hazards and safe work practices for RCF manufacturing and use.

3.2 Potential for Worker Exposure

Approximately 31,500 workers in the United States are potentially exposed to RCFs during manufacturing, processing, or end use. A similar number of workers are potentially exposed to RCFs in Europe. Of these workers, about 800 (3%) are employed in the actual manufacturing of RCFs and RCF products [Maxim et al. 1997; RCFC 2004].

3.3 RCF Manufacturing Process

The manufacture of RCFs (Figure 3–1) begins by blending raw materials, which may include kaolin clay, alumina, silica, and zirconia in a batch house. The batch mix is then transferred either manually or automatically to a furnace to be melted at temperatures exceeding 1,600 °C. On reaching a specified temperature and viscosity in the furnace, the molten

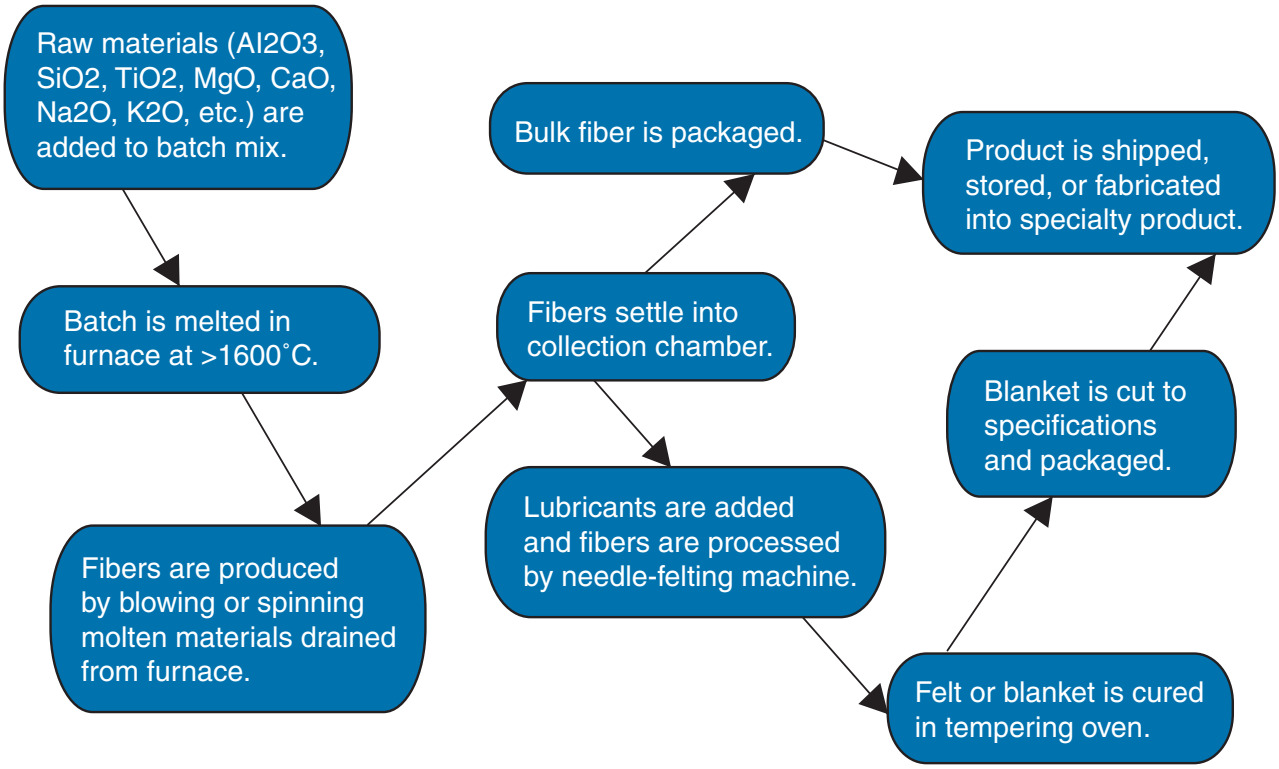

Figure 3–1. Process flow chart for RCF production.

batch mixture drains from the furnace and is fiberized, either through exposure to pressurized air or by flowing through a series of spinning wheels [Hill 1983]. Fans are used to create a partial vacuum that pulls the fibers into a collection or settling chamber. RCFs may then be conveyed pneumatically to a bagging area for packaging as bulk fiber. Some bulk fiber may be used directly in this form, or it may be processed to form textiles, felts, boards, cements, and other specialty items. Other RCFs are formed into blankets as bulk fiber in the collection chamber settles onto a conveyor belt. The blanket passes through a needle felting machine that interlocks the fibers and compresses the blanket to a specified thickness. From the needler, the blanket is conveyed to a tempering oven to remove lubricants that were added in the settling chamber. The lubricants are burned off, and the blanket is cut to desired size and packaged. As with the bulk fiber, the RCF blanket may undergo additional fabrication to create other specialty products. Many of the processes are automated and are monitored by machine operators. Postproduction processes such as cutting, sanding, packaging, handling, and shipping are more labor intensive, but the potential exists for exposure to airborne fibers throughout production.

3.4 RCF Products and Uses

RCFs may be used in bulk fiber form or as one of the RCF specialty products in the form of mats, paper, textiles, felts, and boards [RCFC 1996]. Because of its ability to withstand temperatures exceeding 1,000 °C, RCFs are used predominantly in industrial applications, including insulation, reinforcement, and thermal protection for furnaces and kilns. RCFs can also be found in automobile catalytic converters, in consumer products that operate at high temperatures (e.g., toasters, ovens, woodstoves), and in space shuttle tiles. RCFs have been formed into noise-control blankets [Thornton et al. 1984] and used as a replacement for refractory bricks in industrial kilns and furnaces [RCFC 1996]. RCFs have found increasing application as reinforcements in specialized metal matrix composites (MMC), especially in the automotive and aerospace industries [Stacey 1988]. A summary of RCF products and applications are provided here.

3.4.1 Examples of Products

- **Blankets**—high-temperature insulation produced from spun RCFs in the form of a mat or blanket
- **Boards**—high-temperature insulation produced from bulk fibers in the form of a compressed rigid board (boards have a higher density than blankets and are used as core material or in sandwich assemblies)
- **Bulk RCFs**—fibers with qualities of high-temperature resistance to be used as feedstock in manufacturing processes or other applications for which product consistency is critical—typically in the manufacture of other ceramic-fiber-based products
- **Ropes and braids**—high-temperature insulation produced by textile operations and used for packing, seals, and wicking applications
- **Woven textiles**—high-temperature insulation produced by textile processes in the form of cloth, tape, or sleeves
- **Papers and felts**—flexible high-temperature insulation produced by papermaking processes and used for seals, gaskets, and other automotive and aerospace applications

- **Vacuum cast shapes**—high-temperature insulation produced by forming specialized shapes on prefabricated molds with wet fibers and then drying them by vacuum and heat, thereby transforming bulk fiber into rigid, shaped products
- **Specialties**—forms (i.e., mixes, cements, and caulking compounds) that contain wet, inorganic binder and are used as protective coating putties as well as adhesives and heat and fire barriers in high-temperature applications
- **Modules**—packaged functional assembly of blanket insulation with hardware for attaching to the surfaces of furnaces and kilns

3.4.2 Examples of Applications

- Insulation linings of high-temperature industrial furnaces and related equipment
- Hot spot repair of industrial furnace linings
- Industrial furnace curtains, gaskets, and seals
- Insulation of pipes, ducts, and cables associated with high-temperature industrial furnaces
- Fire protection for industrial process equipment
- Aircraft and aerospace heat shields
- Commercial and consumer appliances consisting of prefabricated chimneys, pizza ovens, self-cleaning ovens, and wood-burning stoves
- Automobile applications consisting of brake pads, clutch facings, catalytic converters, air bags, shoulder belt controls, and passenger compartment heat shields