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Recommendations for a Refractory Ceramic Fiber (RCF) Standard

The National Institute for Occupational Safety and Health (NIOSH) recommends that exposure to airborne refractory ceramic fibers (RCFs) be controlled in the workplace by implementing the recommendations presented in this document. These recommendations are designed to protect the safety and health of workers for up to a 10-hr work shift during a 40-hr workweek over a 40-year working lifetime. Observance of these recommendations should prevent or greatly reduce the risks of eye and skin irritation and adverse respiratory health effects (including lung cancer) in workers with exposure to airborne RCFs. Preventive efforts are primarily focused on controlling and minimizing airborne fiber concentrations to which workers are exposed. Exposure monitoring, hazard communication, training, respiratory protection programs, and medical monitoring are also important elements of a comprehensive program to protect the health of workers exposed to RCFs. These elements are described briefly in this chapter and in greater detail in Chapter 9.

1.1 Recommended Exposure Limit (REL)

NIOSH recommends that occupational exposures to airborne RCFs be limited to 0.5 fiber per cubic centimeter (f/cm^3) of air as a time-weighted average (TWA) concentration for up to a 10-hr work shift during a 40-hr workweek, measured according to NIOSH Method 7400 (B rules) [NIOSH 1998].

This recommended exposure limit (REL) is intended to reduce the risk of lung cancer,

mesothelioma, and other adverse respiratory health effects (including irritation and compromised pulmonary function) associated with excessive RCF exposure in the workplace. Limiting exposures will also protect workers' eyes and skin from the mechanical irritation associated with exposure to RCFs. In most manufacturing operations, it is currently possible to limit airborne RCF concentrations to $0.5 f/cm^3$ or less. Exceptions may occur during RCF finishing operations and during the installation and removal of RCF products, when the nature of job activities presents a challenge to meeting the REL. For these operations, additional protective measures are recommended. Engineering and administrative controls, respirator use, and other preventive measures should be implemented to minimize exposures for workers in RCF industry sectors where airborne RCF concentrations exceed the REL. NIOSH urges employers to disseminate this information to workers and customers, and RCF manufacturers should convey this information to downstream users. NIOSH also requests that professional and trade associations and labor organizations inform their members about the hazards of exposure to RCFs.

1.2 Definitions and Characteristics

1.2.1 Naturally Occurring Mineral Fibers

Many types of mineral fibers occur naturally. Asbestos is the most prominent of these fibers because of its industrial application. The

asbestos minerals include both the serpentine asbestos (chrysotile) and the amphibole mineral fibers, including actinolite, amosite, anthophyllite, crocidolite, and tremolite [Peters and Peters 1980]. Since ancient times, mineral fibers have been mined and processed for use as insulation because of their high tensile strength, resistance to heat, durability in acids and other chemicals, and light weight. The predominant forms of asbestos mined and used today are chrysotile (~95%), crocidolite (<5%), and amosite (<1%).

For the purposes of this document, naturally occurring mineral fibers are distinguishable from synthetic vitreous fibers (SVFs) based on the crystalline structure of the mineral fibers. This property causes the mineral fibers to fracture longitudinally when subjected to mechanical stresses, thereby producing more fibers of decreasing diameter. By contrast, SVFs are amorphous and fracture transversely, resulting in more fibers of decreasing length until the segments are no longer of sufficient length to be considered fibers. Naturally occurring mineral fibers are generally more durable and less soluble than SVFs, a property that accounts for the biopersistence and toxicity of mineral fibers in vivo.

1.2.2 RCFs

RCFs are a type of SVF; they are amorphous synthetic fibers produced from the melting and blowing or spinning of calcined kaolin clay or a combination of alumina (Al_2O_3) and silicon dioxide (SiO_2). Oxides such as zirconia, ferric oxide, titanium oxide, magnesium oxide, calcium oxide, and alkalis may be added. The percentage of components (by weight) is as follows: alumina, 20% to 80%; silicon dioxide, 20% to 80%; and other oxides in smaller amounts. Like the naturally occurring mineral fibers, RCFs possess the desired qualities

of heat resistance, tensile strength, durability, and light weight. On a continuum, however, RCFs are less durable (i.e., more soluble) than the least durable asbestos fiber (chrysotile) but more durable than most fibrous glass and other types of SVFs.

1.2.3 SVFs

SVFs include a number of manmade (not naturally occurring) fibers that are produced by the melting and subsequent fiberization of kaolin clay, sand, rock, slag, and other materials. The major types of SVFs are fibrous glass, mineral wool (slag wool, rock wool), and ceramic fibers (including RCFs). SVFs are also frequently referred to as manmade mineral fibers (MMMFs) or manmade vitreous fibers (MMVFs).

1.3 Sampling and Analysis

Employers shall perform air sampling and analysis to determine airborne concentrations of RCFs according to NIOSH Method 7400 (B rules) [NIOSH 1998], provided in Appendix A of this document.

1.4 Exposure Monitoring

Employers shall perform exposure monitoring as follows:

- Establish a workplace exposure monitoring program for worksites where RCFs or RCF products are manufactured, handled, used, installed, or removed.
- Include in this program routine area and personal monitoring of airborne fiber concentrations.
- Design a monitoring strategy that can be used to

- evaluate a worker’s exposure to RCFs,
- assess the effectiveness of engineering controls, work practices, and other factors in controlling airborne fiber concentrations, and
- identify work areas or job tasks in which worker exposures are routinely high and thus require additional efforts to reduce them.

1.4.1 Sampling Surveys

Employers shall conduct exposure monitoring surveys to ensure that worker exposures (measured by full-shift samples) do not exceed the REL. Because adverse respiratory health effects may occur at the REL, it is desirable to achieve lower concentrations whenever possible. When workers are potentially exposed to airborne RCFs, employers shall conduct exposure monitoring surveys as follows:

- Collect representative personal samples over the entire work shift [NIOSH 1997a].
- Perform periodic sampling at least annually and whenever any major process change takes place or whenever another reason exists to suspect that exposure concentrations may have changed.
- Collect all routine personal samples in the breathing zones of the workers.
- If workers are exposed to concentrations above the REL, perform more frequent exposure monitoring as engineering changes are implemented and until at least two consecutive samples indicate that exposures no longer exceed the REL [NIOSH 1977a].
- Notify all workers of monitoring results and of any actions taken to reduce their exposures.

- When developing an exposure sampling strategy, consider variations in work and production schedules as well as the inherent variability in most area sampling [NIOSH 1995a].

1.4.1.1 Focused sampling

When sampling to determine whether worker RCF exposures are below the REL, a focused sampling strategy may be more practical than a random sampling approach. A focused sampling strategy targets workers perceived to be exposed to the highest concentrations of a hazardous substance [Leidel and Busch 1994]. This strategy is most efficient for identifying exposures above the REL if maximum-risk workers and time periods are accurately identified. Short tasks involving high concentrations of airborne fibers could result in elevated exposure over full work shifts.

Sampling strategies such as those used by Corn and Esmen [1979], Rice et al. [1997], and Maxim et al. [1997] have been developed and used specifically in RCF manufacturing facilities to monitor airborne fiber concentration. In these strategies, representative workers are selected for sampling and are grouped according to dust zones, uniform job titles, or functional job categories. These approaches are intended to reduce the number of required samples and increase the confidence of identifying workers at similar risk.

1.4.1.2 Area sampling

Area sampling may be useful in exposure monitoring to determine sources of airborne RCFs and to assess the effectiveness of engineering controls.

1.4.2 Action Level

An action level (AL) at half the REL (0.25 f/cm³) shall be used to determine when additional

controls are needed or when administrative actions should be taken to reduce exposure to RCFs. The purpose of an AL is to indicate when worker exposures to hazardous substances may be approaching the REL. When air samples contain concentrations at or above the AL, the probability is high that worker exposures to the hazardous substance exceed the REL.

The AL is a statistically derived concept permitting the employer to have confidence (e.g., 95%) that if results from personal air samples are below the AL, the probability is small that worker exposures are above the REL. NIOSH has concluded that the use of an AL permits the employer to monitor hazardous workplace exposures without daily sampling. The AL concept has served as the basis for defining the elements of an occupational standard in NIOSH criteria documents and comprehensive standards promulgated by the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA).

1.5 Hazard Communication

Employers shall take the following measures to inform workers about RCF hazards:

- Establish a safety and health training program for all workers who manufacture, use, handle, install, or remove RCF products or perform other activities that bring them into contact with RCFs.
- Inform employees and contract workers about hazardous substances in their work areas.
- Instruct workers about how to get information from material safety data sheets (MSDSs) for RCFs and other chemicals.
- Provide MSDSs onsite and make them easily accessible.

- Inform workers about adverse respiratory health effects associated with RCF exposures.
- In work involving the removal of refractory insulation materials, make workers aware of the potential for exposure to respirable crystalline silica, the health effects related to this exposure, and methods for reducing exposures.
- Make workers who smoke cigarettes or use other tobacco products aware of their increased risk of developing RCF-induced respiratory symptoms and conditions (see Sections 1.12 and 9.6 for recommendations about smoking cessation programs).

1.6 Training

Employers shall provide the following training for workers exposed to RCFs:

- Train workers to detect hazardous situations.
- Inform workers about practices or operations that may generate high airborne fiber concentrations (e.g., cutting and sanding RCF boards and other RCF products).
- Train workers how to protect themselves by using proper work practices, engineering controls, and personal protective equipment (PPE).

1.7 Product Formulation

One factor recognized as contributing to the toxicity of an inhaled fiber is its durability and resistance to degradation in the respiratory tract. Chemical characteristics place RCFs among the most durable SVFs. As a result, an

inhaled RCF that is deposited in the alveolar region of the lung will persist longer in the lungs than a less durable fiber. Therefore, NIOSH recommends substituting a less durable fiber for RCFs or reformulating the chemistry of RCFs toward this end to reduce the hazard for exposed workers. As part of product stewardship efforts, several RCF producers within the Refractory Ceramic Fibers Coalition (RCFC) have developed new and less biopersistent fibers termed alkaline earth silicate wools [Maxim et al. 1999b]. Newly developed fibers should undergo industry-sponsored testing before their selection and commercial use to exclude possible adverse health effects from exposure.

1.8 Engineering Controls and Work Practices

1.8.1 Engineering Controls

Employers shall use and maintain appropriate engineering controls to keep airborne concentrations of RCFs at or below the REL during the manufacture, use, handling, installation, and removal of RCF products. Engineering controls for controlling RCFs include the following:

- Local exhaust ventilation or dust collection systems at or near dust-generating systems
 - Band saws used in RCF manufacturing and finishing operations have been fitted with such engineering controls to capture fibers and dust during cutting operations, thereby reducing exposures for the band saw operator [Venturin 1998].
 - Disc sanders fitted with similar local exhaust ventilation systems effectively reduce airborne RCF concentrations

during the sanding of vacuum-formed RCF products [Dunn et al. 2004].

- Enclosed processes used during manufacturing to keep airborne fibers contained and separated from workers
- Water knives, which are high-pressure water jets that effectively cut and trim the edges of RCF blanket while suppressing dust and limiting the generation of airborne fibers

1.8.2 Work Practices

Employers shall implement appropriate work practices to help keep worker exposures at or below the REL for RCFs. The following work practices are recommended to help reduce concentrations of airborne fibers:

- Limit the use of power tools unless they are equipped with local exhaust or dust collection systems.
 - Be aware that manually powered hand tools generate less dust and fewer airborne fibers, but they often require additional physical effort and time and may increase the risk of musculoskeletal disorders.
 - The additional physical effort required by hand tools may also increase the rate and depth of breathing and consequently affect the inhalation rate and deposition of fibers in the lungs.
- Use ergonomically correct tools and proper workstation design to reduce the risk of musculoskeletal disorders.
- Use high-efficiency particulate air-filtered (HEPA-filtered) vacuums.

- Use wet sweeping to suppress airborne fiber and dust concentrations during cleanup.
- When removing after-service RCF products, dampen insulation with a light water spray to prevent fibers and dust from becoming airborne. (However, *use caution when dampening refractory linings during installation*, since water can damage refractory-lined equipment, causing the generation of steam and possible explosion during heating.)
- Clean work areas regularly using a HEPA-filtered vacuum or wet sweeping to minimize accumulation of debris.
- Ensure that workers wear long-sleeved clothing, gloves, and eye protection when performing potentially dusty activities involving RCFs or RCF products. For some activities, disposable clothing or coveralls may be preferred.

1.9 Respiratory Protection

Respirators shall be used while performing any task for which the exposure concentration is unknown or has been documented to be higher than the NIOSH REL of 0.5 f/cm³ as a TWA. However, respirators shall not be used as the primary means of controlling worker exposures.

When possible, use other methods for minimizing worker exposures to RCFs:

- Product substitution
- Engineering controls
- Changes in work practices

Use respirators when available engineering controls and work practices do not adequately

control worker exposures below the REL for RCFs. NIOSH recognizes that controlling exposures to RCFs is a particular challenge during the finishing stages of RCF product manufacturing and during the installation and removal of refractory materials

1.9.1 Respiratory Protection Program

When respiratory protection is needed, employers shall establish a comprehensive respiratory protection program as described in the OSHA respiratory protection standard [29 CFR* 1910.134]. Elements of a respiratory protection program must be established and described in a written plan that is specific to the workplace. The plan must include the following elements:

- Procedures for selecting respirators
- Medical evaluations of workers required to wear respirators
- Fit-testing procedures
- Routine-use procedures and emergency respirator-use procedures
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and maintaining respirators
- Procedures for ensuring adequate air quality for supplied-air respirators
- Training in respiratory hazards
- Training in the proper use and maintenance of respirators
- Program evaluation procedures
- Procedures for ensuring that workers who voluntarily wear respirators (excluding filtering facepieces known as dust masks)

*Code of Federal Regulations. See CFR in references.

comply with the medical evaluation and cleaning, storing, and maintenance requirements of the standard

- A designated program administrator who is qualified to administer the respiratory protection program

Employers shall update the written program as necessary to account for changes in the workplace that affect respirator use. In addition, employers are required to provide at no cost to workers all equipment, training, and medical evaluations required under the respiratory protection program.

1.9.2 Respirator Selection

When conditions of exposure to airborne RCFs exceed the REL, proper respiratory protection shall be selected as follows:

- Select, at a minimum, a half-mask, air-purifying respirator equipped with a 100 series particulate filter. This respirator has an assigned protection factor (APF) of 10.
- Provide a higher level of protection and prevent facial or eye irritation from RCF exposure by using a full-facepiece, air-purifying respirator equipped with a 100-series filter; or use any powered, air-purifying respirator equipped with a tight-fitting facepiece (full-facepiece).
- Consider providing a supplied-air respirator with a full facepiece for workers who remove after-service RCF insulation (e.g., furnace insulation) and are therefore exposed to high and unpredictable concentrations of RCFs. These respirators provide a greater level of respiratory protection. Use them whenever the work task involves potentially high concentrations of airborne fibers.

- Always perform a comprehensive assessment of workplace exposures to determine the presence of other possible contaminants (such as silica) and to ensure that proper respiratory protection is used.
- Use only respirators approved by NIOSH and MSHA.

For information and assistance in establishing a respiratory protection program and selecting appropriate respirators, see the OSHA *Respiratory Protection Advisor* on the OSHA Web site at www.osha.gov. Additional information is also available from the *NIOSH Respirator Selection Logic* [NIOSH 2004], the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987b], and the *NIOSH Guide to the Selection and Use of Particulate Respirators Certified under 42 CFR 84* [NIOSH 1996].

1.10 Sanitation and Hygiene

Employers shall take the following measures to protect workers potentially exposed to RCFs:

- Do not permit smoking, eating, or drinking in areas where workers may contact RCFs.
- Provide showering and changing areas free from contamination where workers can store work clothes and change into street clothes before leaving the work site.
- Provide services for laundering work clothes so that workers do not take contaminated clothes home.
- Protect laundry workers handling RCF-contaminated clothes from airborne concentrations that are above the REL.

Workers shall take the following protective measures:

- Do not smoke, eat, or drink in areas potentially contaminated with RCFs.
- If fibers get on the skin, wash with warm water and mild soap.
- Apply skin-moisturizing cream or lotion as needed to avoid irritation caused by frequent washing.
- Wear long-sleeved clothing, gloves, and eye protection when performing potentially dusty activities involving RCFs.
- Vacuum this clothing with a HEPA-filtered vacuum before leaving the work area.
- Do not use compressed air to clean the work area or clothing and do not shake clothing to remove dust. These processes will create a greater respiratory hazard with airborne dust and fibers.
- Do not wear work clothes or protective equipment home. Change into clean clothes before leaving the work site.

1.11 Medical Monitoring

Medical monitoring (in combination with resulting intervention strategies) represents secondary prevention and should not replace primary prevention efforts to control airborne fiber concentrations and worker exposures to RCFs. However, compliance with the REL for RCFs (0.5 f/cm^3) does not guarantee that all workers will be free from the risk of RCF-induced respiratory irritation or respiratory health effects. Therefore, medical monitoring is especially important, and employers shall establish a medical monitoring program as follows:

- Collect baseline data for all employees before they begin work with RCFs.
- Continue periodic medical screening throughout their lifetime.
- Use medical surveillance, which involves the aggregate collection and analysis of medical screening data, to identify occupations, activities, and work processes in need of additional primary prevention efforts.
- Include all workers potentially exposed to RCFs (in both manufacturing and end-use industries) in an occupational medical monitoring program.
- Provide workers with information about the purposes of medical monitoring, the health benefits of the program, and the procedures involved.
- Include the following workers (who could receive the greatest benefits from medical screening) in the medical monitoring program:
 - Workers exposed to elevated fiber concentrations (e.g., all workers exposed to airborne fiber concentrations above the AL of 0.25 f/cm^3 , as described in Section 9.3)
 - Workers in areas or in specific jobs and activities (regardless of airborne fiber concentration) in which one or more workers have symptoms or respiratory changes apparently related to RCF exposure
 - Workers who may have been previously exposed to asbestos or other recognized occupational respiratory hazards that place them at an increased risk of respiratory disease

1.11.1 Oversight of the Program

Assign oversight of the medical monitoring program to a qualified physician or other qualified health care provider (as determined by appropriate State laws and regulations) who is informed and knowledgeable about the following:

- Administering and managing a medical monitoring program for occupational hazards
- Establishing a respiratory protection program based on an understanding of requirements of the OSHA respiratory protection standard and types of respiratory protection devices available at the workplace
- Identifying and managing work-related respiratory effects or illnesses
- Identifying and managing work-related skin diseases

1.11.2 Elements of the Medical Monitoring Program

Include the following elements in a medical monitoring program for workers exposed to RCFs: (1) an initial medical examination, (2) periodic medical examinations at regularly scheduled intervals, (3) more frequent and detailed medical examinations as needed on the basis of the findings from these examinations, (4) worker training, (5) written reports of medical findings, (6) quality assurance, and (7) evaluation. These elements are described in the following subsections.

1.11.2.1 Initial (baseline) examination

Perform an initial (baseline) examination as near as possible to the date of beginning employment (within 3 months) and include the following:

- A physical examination of all systems with an emphasis on the respiratory system and the skin
- A spirometric test (note that anyone administering spirometric testing as part of the medical monitoring program should have completed a NIOSH-approved training course in spirometry or other equivalent training)
- A chest X-ray (all chest X-ray films should be interpreted by a certified NIOSH B Reader using the standard *International Classification of Radiographs of Pneumoconioses* [ILO 2000, or the most recent equivalent])
- Other medical tests as deemed appropriate by the responsible health care professional
- A standardized respiratory symptom questionnaire, such as the American Thoracic Society respiratory questionnaire [Ferris 1978, or the most recent equivalent]
- A standardized occupational history questionnaire that gathers information about all past jobs with (1) special emphasis on those with potential exposure to dust and mineral fibers, (2) a description of all duties and potential exposures for each job, and (3) a description of all protective equipment the worker has used

1.11.2.2 Periodic examinations

Administer periodic examinations (including a physical examination of the respiratory system and the skin, spirometric testing, a respiratory symptom update questionnaire, and an occupational history update questionnaire) at regular intervals determined by the medical monitoring program director. Determine the

frequency of the periodic medical examinations according to the following guidelines:

- For workers with fewer than 10 years since first exposure to RCFs, conduct periodic examinations at least once every 5 years.
- For workers with 10 or more years since first exposure to RCFs, conduct periodic examinations at least once every 2 years.

A chest X-ray and spirometric testing are important on initial examination and may also be appropriate medical screening tests during periodic examinations for detecting respiratory system changes, especially in workers with more than 10 years since first exposure to RCFs. A qualified health care provider should consult with the worker to determine whether the benefits of periodic chest X-rays warrant the additional exposure to radiation.

1.11.2.3 More frequent evaluations

Workers may need to undergo more frequent and detailed medical evaluations if the attending physician determines that he or she has any of the following indications:

- New or worsening respiratory symptoms or findings (e.g., chronic cough, difficult breathing, wheezing, reduced lung function, or radiographic indications of pleural plaques or fibrosis)
- History of exposure to other respiratory hazards (e.g., asbestos)
- Recurrent or chronic dermatitis
- Other medically significant reason(s) for more detailed assessment

1.11.2.4 Worker training

Provide workers with sufficient training to recognize symptoms associated with RCF

exposures (e.g., chronic cough, difficult breathing, wheezing, skin irritation). Instruct workers to report these symptoms to the designated medical monitoring program director or other qualified health care provider for appropriate diagnosis and treatment.

1.11.2.5 Written reports of medical findings

Following initial and periodic medical examinations, the physician or other qualified health care provider shall give each worker a written report containing

- results of any medical tests performed on the worker,
- a medical opinion in plain language about any medical condition that would increase the worker's risk of impairment from exposure to airborne RCFs,
- recommendations for limiting the worker's exposure to RCFs (which may include the use of appropriate PPE, as warranted), and
- recommendations for further evaluation and treatment of any medical conditions detected.

Following initial and periodic medical examinations, the physician or other qualified health care provider shall also give a written report to the employer containing

- occupationally pertinent results of the medical evaluation,
- a medical opinion about any medical condition that would increase the worker's risk of impairment from exposure to airborne RCFs,
- recommendations for limiting the worker's exposure to RCFs or other

agents in the workplace (which may include the use of appropriate PPE or reassignment to another job), and

- a statement to indicate that the worker has been informed about the results of the medical examination and about any medical condition(s) that should have further evaluation or treatment.

Findings, test results, or diagnoses that have no bearing on the worker's ability to work with RCFs shall not be included in the report to the employer. Safeguards to protect the confidentiality of the worker's medical records shall be enforced in accordance with all applicable regulations and guidelines.

1.11.2.6 Quality assurance

Employers shall do the following to ensure the effective implementation of a medical monitoring program:

- Ensure that workers follow the qualified health care provider's recommended exposure restrictions for RCFs and other workplace hazards.
- Ensure that workers use appropriate PPE if they are exposed to RCF concentrations above the REL.
- Encourage workers to participate in the medical monitoring program and to report any symptoms promptly to the program director.
- Provide any medical evaluations that are part of the medical monitoring program at no cost to the workers.
- When implementing job reassignments recommended by the medical program director, ensure that workers do not lose wages, benefits, or seniority.

- Ensure that the medical monitoring program director communicates regularly with the employer's safety and health personnel (e.g., industrial hygienists) to identify work areas that may require control measures to minimize exposures to workplace hazards.

1.11.2.7 Evaluation

Employers shall evaluate their medical monitoring programs as follows:

- Periodically have standardized medical screening data aggregated and evaluated by an epidemiologist or other knowledgeable person to identify patterns of worker health that may be linked to work activities and practices requiring additional primary preventive efforts.
- Combine routine aggregate assessments of medical screening data with evaluations of exposure monitoring data to identify needed changes in work areas or exposure conditions.

1.12 Labeling and Posting

Employers shall post warning labels and signs as follows:

- Post warning labels and signs describing the health risks associated with RCFs at entrances to work areas and inside work areas where airborne concentrations of RCFs may exceed the REL.
- Depending on work practices and the airborne concentrations of RCFs, state on the signs the need to wear protective clothing and the appropriate respiratory protection for RCF exposures above the REL.

- If respiratory protection is required, post the following statement:

**RESPIRATORY PROTECTION
REQUIRED IN THIS AREA**

- Print all labels and warning signs in both English and the predominant language of workers who do not read English.
- Verbally inform workers about the hazards and instructions printed on the labels and signs if they are unable to read them.

1.13 Smoking Cessation

NIOSH recognizes a synergistic effect between exposure to RCFs and cigarette smoking. This effect increases the risk of adverse respiratory health effects induced by RCFs. In studies of workers exposed to various airborne contaminants, combined exposures to smoking and airborne dust have been shown to contribute to the increased risk of occupational respiratory diseases, including chronic bronchitis, emphysema, and lung cancer [Morgan 1994; Barnhart 1994].

Employers shall encourage smoking cessation among RCF-exposed workers as follows:

- Establish smoking cessation programs to inform workers about the increased hazards of cigarette smoking and exposure to RCFs.
- Provide assistance and encouragement for workers who want to quit smoking.
- Prohibit smoking in the workplace.
- Disseminate information about health promotion and the harmful effects of smoking.
- Offer smoking cessation programs to workers at no cost to participants.
- Encourage activities that promote physical fitness and other healthy lifestyle practices affecting respiratory and cardiovascular health (e.g., through training programs, employee assistance programs, and health education campaigns).

NIOSH recommends that all workers who smoke and are potentially exposed to RCFs participate in smoking cessation programs.