Reducing Worker Exposure to Refractory Ceramic Fibers

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

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Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

Refractory ceramic fibers (RCFs) belong to a broad group of materials called synthetic vitreous fibers, which includes many different types of manufactured fibers produced by the melting and subsequent fiberization of kaolin clay, sand or other naturally occurring minerals. Also referred to as man-made mineral fiber (MMMF) or man-made vitreous fiber, some common examples include fiberglass, mineral wool and alkaline earth silicate wool.

Specifically, RCFs are a group of man-made amorphous or crystalline fibers typically produced through melting and spinning silicon oxide, aluminum oxide and certain other metal oxides to form a lightweight fiber.

RCFs are widely used in the steelmaking industry due to their physical properties, which include low thermal conductivity and high thermal shock resistance. Uses of RCFs include high-performance and high-temperature insulation materials for furnace linings, ladle covers, heat curtains and mold linings, to name a few. RCFs, along with other high-temperature insulating wool, provide many benefits to the steel production and casting industry. These include protecting workers, equipment and property from excessive heat, improving the efficiency of furnaces and process equipment, and reducing energy usage.

However, like other man-made and naturally occurring fibers, they can become friable (easily broken or crumbled) when cut or damaged, or when they are at the end of useful life and pose an exposure and health risk to workers.

Health Effects and Exposure Limits

Health effects from exposure to RCFs can include skin itching and irritation due to contact with fibers. These fibers can also cause irritation of the eyes, nose and throat, which may lead to coughing and discomfort. These effects are typically temporary and dissipate after exposure.[4]

More concerning is exposure through inhalation of respirable dust and fibers. In addition to irritation of the respiratory tract, the National Institute for Occupational Safety and Health (NIOSH) has determined that occupational exposure to RCFs is associated with adverse respiratory effects, and may pose a carcinogenic risk based on the results of chronic animal inhalation studies.[1]

Several agencies have established occupational exposure limits (OELs) for refractory ceramic fibers, both compulsory and voluntary. These OELs are summarized in Table 1.[2]

Currently the U.S. Occupational Safety and Health Administration (OSHA) does not have specific exposure limits for refractory ceramic fibers, relying instead on the permissible exposure limit (PEL) of 15 mg/m^3 (5 mg/m^3 respirable) 8-hour total weight average (TWA) limit for total respirable dusts and particulates not otherwise regulated. However, OSHA has endorsed the High Temperature Insulation Wool (HTIW) Coalition voluntary product stewardship program (PSP 2017) for RCF products.[5] The product stewardship program establishes a Recommended Exposure Guideline (REG) of 0.5 fibers per cubic centimeter (f/cm^3) respirable refractory ceramic fibers, consistent

Table 1

Summary of Published Occupational Exposure Limits: 8-Hour Time-Weighted Average (TWA)

Federal OSHA PEL Inert or nuisance dust	15 mg/m^3 Total dust 5 mg/m^3 respirable fraction
ACGIH TLV Refractory ceramic fibers	0.2 f/cc (1) A2 - Suspected Human Carcinogen
NIOSH REL Synthetic vitreous fibers	5 mg/m^3 (total) 3 f/cm^3 (2)
State of California PEL Refractory ceramic fibers	0.2 f/cc (3)

1. Respirable fibers > 5 µm aspect ratio ≥ 3:1 as determined by the membrane filter method at 400–450X magnification (4 mm objective), using phase contrast illumination.
2. Fibers ≤ 3.5 µm in diameter and ≥ 10 µm in length.
3. Fibers per cubic centimeter of air at 25°C and 760 mm Hg pressure. To be considered a fiber for this limit the glass particle must be longer than 5 µm, have a length to diameter ratio of 3 or more, and have a diameter less than 3 µm.

with the proposed NIOSH recommended exposure limit (REL) in the 2006 NIOSH Criteria Document for occupational exposure to RCF.

Both California OSHA and the American Conference of Government Industrial Hygienists (ACGIH®) have established a TWA OEL of 0.2 f/cm^3.[3] This limit is primarily based on lung function changes and pleural thickening observed in RCF production workers. ACGIH has also designated refractory ceramic fibers as a suspected human carcinogen.[4] NIOSH has established a recommended exposure limit (REL) of 3 f/cm^3 for synthetic vitreous fibers as a 10-hour TWA. In 2006, NIOSH proposed an REL of 0.5 f/cm^3 for respirable refractory ceramic fibers, further stating that due to a residual risk of cancer that may still exist at this level, efforts should be made toward reducing exposures to less than 0.2 f/cm^3.[1]

Workplace Exposure Controls

Employers using RCF insulation or handling RCF-containing products during insulation installation or removal should assess worker exposures to RCF dust and fibers. When assessing worker exposures to RCF, respirable fiber counts are preferred over gravimetric measurements. Employers should also be aware that RCF insulation exposed to temperatures more than 900°C may see some conversion of amorphous silica to crystalline silica. Bulk material testing or air sampling methods can be used to determine crystalline silica content. If respirable crystalline silica is present, refer to the OSHA respirable crystalline silica standard, 29 CFR 1910.1053, for employer requirements.

Exposures should be controlled using a combination of engineering and administrative controls. Engineering controls include adequate general dilution ventilation, use of local exhaust ventilation for point of generation dust control and use of power tools with emission controls to minimize dust/fiber generation during cutting and shaping of insulation products. Administrative controls can include proper work and material handling procedures, worker training, and good housekeeping practices.

Suggested Material Handling and Housekeeping Practices

- Limit use of power tools unless in conjunction with local exhaust ventilation. Use hand tools whenever possible.
- During handling or transport, avoid contact with rough surfaces and avoid dragging materials. Pieces should be fully lifted to help prevent release of fibers.
- Use a brush under local exhaust ventilation or a HEPA vacuum to clean insulation products of excess dust after cutting or machining.
- Do not use compressed air to clean product or work areas.
- Clean work areas with a HEPA vacuum. If sweeping must be used, utilize wet sweeping methods.
- Clear waste insulation materials and clean work areas regularly.

Personal Protective Equipment (PPE)

When engineering and/or administration controls are not adequate or feasible to control worker exposures to RCF, use of appropriate and properly selected PPE can be utilized. Gloves and protective clothing should be worn to help prevent skin contact. Either disposable or reusable (launderable) clothing can be used. If using launderable clothing, take care not to carry RCF into areas where others may be exposed. Dedicated changing areas and laundry facilities are recommended. In addition, proper donning/doffing techniques can help minimize release of fibers.

Proper eye protection should be used when performing activities that generate RCF dust and fibers, and with some operations safety glasses may be sufficient. However, in operations that generate larger amounts of dust, a dust goggle may be the better option. A face shield can also be used to provide additional protection for eyes and face. Reducing risk of eye contact from extremely small particles can be difficult to address as these particles tend to stay suspended in air longer and can accumulate on top of hard surfaces, including hard hats. These fine particles can sometimes reach the eyes through gaps between the eyewear frame and workers' skin. Recent advances in safety eyewear design, including foam linings on safety glasses and safety goggles, can help prevent these fine particles from reaching the eyes.

In the U.S., if respiratory protection is required, the employer must implement an effective written respiratory protection program in accordance with requirements in OSHA's Respiratory Protection Standard 29 CFR 1910.134. A particulate respirator with a minimum filter efficiency of 95% is recommended for filtering of RCFs (NIOSH Respirator Selection Logic 2004). Measured airborne fiber concentrations should be used as the basis for determining the appropriate respirator with the minimum assigned protection factor needed to reduce exposures to an acceptable level. A recent trend seen in many industries, especially in the metal and metalworking industry, is the use of integrated respiratory protection. Integrated respiratory protection is a single system that includes a powered air-purifying or supplied-air respirator with a loose-fitting helmet. This type of system has the advantage of a higher protection factor (APF of 25 or 1000) with integrated American National Standard Institute (ANSI) head, eye and face protection. Some integrated systems also allow ear muffs to be attached to a helmet when hearing protection is required, and can include a shroud to provide some protection of the neck and shoulders.

If PPE is used to help protect workers, a complete hazard and exposure assessment and a certification of hazard assessment must be completed as specified in 29 CFR 1910.132.

Conclusion

There is no doubt that insulating materials manufactured with RCFs provide the steel industry with many benefits associated with thermal heat management and energy savings. While there are inherent risks associated with the use and handling of these materials, proper worker training, material handling, housekeeping and maintenance procedures can be used to reduce these risks and help provide a safe working environment.

References

1. "Criteria for a Recommended Standard: Occupational Exposure to Refractory Ceramic Fibers," Department of Health and Human Services, Centers for Disease Control and Prevention, and National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2006–123, May 2006.
2. "Exposure Limits for Synthetic Mineral Fibers," U.S. Department of Labor, Occupational Safety and Health Administration, https://www.osha.gov/SLTC/syntheticmineralfibers/table.html.
3. "Table AC-1 Permissible Exposure Limits for Chemical Contaminants," California Code of Regulations, Title 8, Section 5155, https://www.dir.ca.gov/title8/5155table_ac1.html.
4. "Documentation of the Threshold Limit Values and Biological Exposure Indices, Synthetic Vitreous Fibers," ACGIH® American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 2001.
5. "High Temperature Insulation Wool (HTIW) Coalition," http://www.htiwcoalition.org. ✦

Did You Know?

Butech Bliss Completes the Installation of Custom Steel Processing's New Stretch Leveling Cut-to-Length Line

Butech Bliss recently completed the design, manufacture and installation of a high-production stretch leveling cut-to-length line for Custom Steel Processing's new coil processing center in Granite City, Ill., USA.

The line will process a wide range of products including hot-rolled carbon steel, hot-rolled pickled and oiled (HRPO) steel, cold-rolled steel and galvanized steel up to 1 inch thick and 74 inches wide. This state-of-the-art line includes Butech Bliss' patented Synergy® leveling system with roll cartridge system and high-production stretch leveler with non-marking gripper heads.

The line also features sidetrimming capacity up to 3/8 inch with scrap handling system; a Butech Bliss dual-arbor shimless scrap chopper; and brush roll scale collection system, among other features.

Custom Steel Processing recently purchased their second facility where the new line will be located. The heavy-gauge high-production stretch leveling line will expand their product offering in the marketplace as one of the heaviest-gauge stretch levelers in the country and is centrally located to serve customers in the Midwest.

Jock Buta, executive vice president at Butech Bliss, said, "We are excited to be a part of this project because it matches our strengths as a manufacturer of heavy-gauge coil processing equipment with one of Custom Steel Processing's needs in an important core business segment."