



Standard Practice for Handling Silicon Carbide Whiskers¹

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1. Scope

1.1 This practice covers recommended procedures to reduce health and safety problems which may arise during handling of respirable silicon carbide whiskers. Respirable silicon carbide whiskers are a crystalline silicon carbide (SiC) fiber, approximately cylindrical in shape with a diameter less than 3.0 μm and an aspect ratio equal to or greater than 5:1.

1.2 Fragments of longer silicon carbide fibers that meet the size definition of respirable silicon carbide whiskers are covered by this practice.

1.3 Mixtures of respirable and non-respirable whiskers or fibers, or both, are covered by this practice.

1.4 The information contained in this practice may be considered for use in a material safety data sheet (MSDS) for silicon carbide whiskers.

1.5 Other materials may be present in the final product (for example, crystalline silica); information specific to these additional materials should be included in each manufacturer's MSDS.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard and precaution statements, see Sections 5, 7, 9, and 10.

2. Referenced Documents

2.1 ASTM Standards:

- D 6056 Test Method for Determining the Concentration of Airborne Single-Crystal Ceramic Whiskers in the Workplace Environment by Transmission Electron Microscopy²
- D 6057 Test Method for Determining the Concentration of Airborne Single-Crystal Ceramic Whiskers in the Workplace Environment by Phase Contrast Microscopy²
- D 6058 Test Method for Determining the Concentration of Airborne Single-Crystal Ceramic Whiskers in the Workplace Environment²

- D 6059 Test Method for Determining the Concentration of Airborne Single-Crystal Ceramic Whiskers in the Workplace Environment by Scanning Electron Microscopy²
- E 1435 Practice for Handling Densified Articles of Aluminum Oxide Reinforced with Silicon Carbide Whiskers²
- E 1451 Guide for Disposal of Wastes Containing Respirable Silicon Carbide Whiskers²
- E 1516 Guide for Packaging of Unbound Respirable Silicon Carbide Whiskers²
- E 1576 Guide for Medical Surveillance Program for Workers with Occupational Exposure to Airborne Silicon Carbide Whiskers and Fibers²
- E 1716 Guide for Selection and Use of Personal Protective Equipment for Humans Working with Respirable Silicon Carbide Whiskers²
- E 1717 Guide for Personnel Training for Health and Safety Aspects of Working in Environments Containing Respirable Silicon Carbide Whiskers²
- E 1718 Guide for Administrative and Engineering Controls for Silicon Carbide Whisker Work Areas²
- 2.2 *American National Standards Institute (ANSI) Standards:*³
 - ANSI Z88.2—1992, Respiratory Protection
 - ANSI Z9.2—1979, Fundamentals Governing the Design and Operation of Local Exhaust Systems
- 2.3 *Occupational Safety and Health Administration (OSHA) Standard:*⁴
 - U.S. Code of Federal Regulations (CFR) 29 CFR 1910.134, Respiratory Protection

3. Terminology

3.1 Definitions:

- 3.1.1 *aspect ratio, n*—ratio of whisker length to whisker diameter.
- 3.1.2 *HEPA, n*—disposable extended media dry-type, high-efficiency, particulate air filter with a particulate removal of no less than 99.97 % for 0.3 μm diameter particles.⁵

¹ This practice is under the jurisdiction of ASTM Committee E34 on Occupational Health and Safety and is the direct responsibility of Subcommittee E34.70 on Single Crystal Ceramic Whiskers.

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² *Annual Book of ASTM Standards*, Vol 11.03.

³ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10038.

⁴ Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

⁵ *Fundamentals of Industrial Hygiene*, 4th ed., National Safety Council, 1121 Spring Lake Dr., Itasca, IL 60143-3201.

3.1.3 *respirable silicon carbide whiskers, n*—a crystalline silicon carbide fiber, approximately cylindrical in shape, with a diameter less than 3.0 μm and an aspect ratio equal to or greater than 5:1.

4. Significance and Use

4.1 Workers may be exposed to respirable SiC whiskers during handling, processing, or use of SiC whiskers or powdered blends containing SiC whiskers. Exposure may also occur during (re)finishing of consolidated or densified articles when respirable SiC whiskers are released.

4.2 This practice provides guidance for handling, processing, or use of SiC whiskers, either alone or combined with other materials. It is intended for use by health and safety professionals in determining whether an excessive exposure exists, in preparing procedures to establish a safe work environment, and in preparing relevant documentation.

4.3 Users of this practice are directed to the following ASTM standards as supplemental information: Test Methods D 6056, D 6057, D 6058, and D 6059; Practice E 1435; and Guides E 1451, E 1516, E 1576, E 1716, E 1717, and E 1718.

5. Hazardous Ingredients/Identity Information

5.1 *Hazardous Ingredients* (specific chemical identity common name(s))—Silicon carbide whiskers, an acicular form of silicon carbide, which is Chemical Abstract Service (CAS) 409-21-2. A CAS number specific to SiC whiskers has not been assigned. OSHA Permissible Exposure Limits (PELs) for SiC whiskers have not been established. American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) have not been established. Manufacturers currently use the following exposure limits for respirable SiC whiskers.

5.1.1 A short term exposure limit (STEL) for respirable SiC whiskers of 2 fibers/cc as averaged over a sampling period of 30 min.

5.1.2 A long term exposure limit for respirable SiC whiskers of 0.2 fibers/cc 8-h time weighted average (TWA).

5.2 Silicon carbide whiskers are not classified by OSHA or the U.S. National Toxicology Program (NTP) as a carcinogen; however, the International Agency for Research on Cancer (IARC) classified the family of ceramic fibers, which contains SiC whiskers, in Group 2B as *possibly carcinogenic* to humans. (Group 2B: “There is sufficient evidence for the carcinogenicity of ceramic fibers in experimental animals; no data were available on the carcinogenicity of ceramic fibers to humans.”)⁶

6. Physical/Chemical Characteristics

6.1 The following data are relevant when preparing an MSDS for SiC whiskers:

6.1.1 *Boiling Point*—Not applicable.

6.1.2 *Vapor Pressure (mm Hg)*—Not applicable.

6.1.3 *Vapor Density (AIR = 1)*—Not applicable.

6.1.4 *Solubility in Water*—Insoluble.

6.1.5 *Relative Density (specific gravity)*—3.2.

6.1.6 *Oxidation*—Occurs above 700°C.

6.1.7 *Melting Point*—Decomposes above 2500°C.

6.1.8 *pH*—Not applicable.

6.1.9 *Evaporation Rate (butyl acetate = 1)*—Not applicable.

6.1.10 *Appearance and Odor*—Variable, typically green to gray-green powder. No odor.

7. Fire and Explosion Hazard Data

7.1 The following data are relevant when preparing an MSDS for SiC whiskers:

7.1.1 *Flash Point*—Non-flammable by conventional test methods.

7.1.2 *Flammable Limits*—Non-flammable.

7.1.3 *Lower Explosive Limit (LEL)*—Not applicable.

7.1.4 *Upper Explosive Limit (UEL)*—Not applicable.

7.1.5 *Extinguishing Media*—Use extinguishing media appropriate for the surrounding materials.

7.1.6 *Special Fire Fighting Procedures*—Avoid actions that would cause whiskers to become airborne. Wear pressure-demand, self-contained breathing apparatus and full fire fighting protective clothing.

7.1.7 *Unusual Fire and Explosion Hazards*—Negligible fire and explosion hazard when whiskers alone are exposed to heat and flame.

NOTE 1—This section is applicable for fire and explosion hazards only and is not to be used for occupational exposures.

8. Reactivity Data

8.1 The following data are relevant when preparing an MSDS for SiC whiskers:

8.1.1 *Stability*—Stable.

8.1.2 *Conditions to Avoid*—None.

8.1.3 *Incompatibility*—None.

8.1.4 *Hazardous Polymerization*—Will not occur.

9. Health Hazard Data

9.1 *General*—Potential route(s) of entry are inhalation and ingestion.

9.2 *Health Hazard and Signs or Symptoms of Overexposure:*

9.2.1 *Acute (short term) Overexposure:*

9.2.1.1 *Skin Absorption*—Skin absorption of this material is unlikely.

9.2.1.2 *Skin Contact*—May cause irritation or rash.

9.2.1.3 *Eye Contact*—May cause irritation.

9.2.1.4 *Ingestion*—There is insufficient information on this material to predict the harmful effect by ingestion.

9.2.1.5 *Inhalation*—Overexposure may cause coughing, mucous production, shortness of breath, irritation of breathing passages, and may result in lung disease.

9.2.2 *Chronic (long term) Overexposure*—Prolonged overexposure may result in progressive and irreversible lung disease.

9.2.3 *Carcinogenicity*—Silicon carbide whiskers are not classified by OSHA or NTP as a carcinogen; however, IARC classified the family of ceramic fibers, which contains SiC

⁶ “Man-Made Mineral Fibres and Radon,” Monograph on the Evaluation of Carcinogenic Risks to Humans, Vol 43, 1988, International Agency for Research on Cancer (IARC), 150 cours Albert-Thomas, 69372 Lyon Cedex 08, France. Also available from World Health Organization, Publications Ctr., 49 Sheridan Ave., Albany, NY 12216.

whiskers, in Group 2B as *possibly carcinogenic* to humans. (Group 2B: “There is *sufficient evidence* for the carcinogenicity of ceramic fibers in experimental animals; no data were available on the carcinogenicity of ceramic fibers to humans.”)⁶

9.3 Medical Conditions Generally Aggravated By Exposure—Chronic respiratory disease such as bronchial hyperactivity and chronic bronchial or lung disease may be aggravated by exposure. The risk of lung cancer has been shown to be increased by smoking in conjunction with exposure to airborne mineral fibers of similar geometry to SiC whiskers.

9.4 Emergency First Aid Procedures:

9.4.1 Inhalation—If symptoms of pulmonary involvement develop (coughing, wheezing, or shortness of breath), remove immediately from the exposure area to fresh air. If symptoms persist, seek medical attention.

9.4.2 Skin Contact—Seek medical attention for symptomatic treatment.

9.4.3 Eye Contact—If irritation occurs, wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, until no evidence of material remains (approximately 15 to 20 min). If symptoms persist, seek medical attention.

10. Precautions for Safe Handling and Use

10.1 Steps to be Taken in Case Material is Released or Spilled—Use a respirator during cleanup. Do not sweep. Use a HEPA filtered vacuum cleaner if vacuuming. To minimize dust generation, wet down spillage with low-velocity fine mist water spray.

10.2 Waste Disposal Method—Spillage, emission control dust, or unused materials may be disposed in a permitted sanitary landfill in accordance with federal, state, county, and local solid waste regulations. Disposal containers should be sealed to prevent airborne emissions during transportation and at the disposal site. It is recommended that disposal containers be labeled externally to warn of a potential airborne fiber inhalation hazard, if dispersed. See Guide E 1451 for waste material disposal guidelines.

10.3 Handling and Storing Precautions—Avoid working with whiskers in a fashion whereby the whiskers may become airborne during any processing stage. Use a respirator when required by 11.1. Take special precautions to avoid contamination of clothing. Identify the contents of all containers and attach a label such as that shown in Fig. 1.

11. Personal Protective Equipment and Control Measures

11.1 Respiratory Protection—It is recommended that engineering controls, rather than administrative controls, be used to

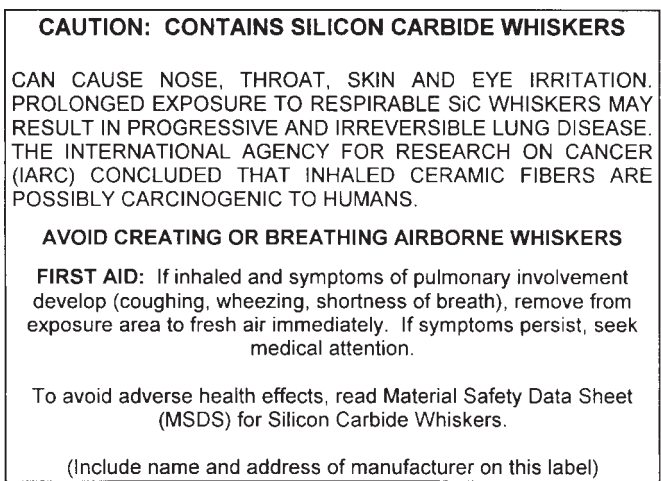


FIG. 1 Label for Identifying Contents

minimize employee exposure. If airborne concentrations exceed the limits of Section 5, a suitable respirator should be worn. Suitable respirators should be worn in accordance with ANSI Z88.2 protocol and OSHA 29 CFR 1910.134.

11.2 Eye Protection—Yes.

11.3 Ventilation—The ventilation should be designed and applied in a manner consistent with the guidelines in Guide E 1718, ANSI Z9.2—1979, the ACGIH Manual, Industrial Ventilation⁷ or other similar guideline applicable to the ventilation task.

11.3.1 Local Exhaust—As required to maintain exposure levels as stated in Section 5.

11.3.2 Mechanical (General)—As required to minimize migration of whiskers out of the controlled area.

11.4 Other Personal Protective Equipment—As needed to minimize exposure or contamination.

11.5 Work and Hygienic Practices—No eating, drinking, smoking, or chewing is permissible in the whisker processing area. Use good hygiene practices when entering or exiting the control zone.

12. Keywords

12.1 carcinogen; ceramic; fiber; health hazard; man-made mineral fiber (MMMF); material safety data sheet (MSDS); respirable; silicon carbide; whisker

⁷ *Industrial Ventilation, A Manual of Recommended Practice*, American Conference of Government Industrial Hygienists (ACGIH), 1330 Kemper Meadow Dr., Cincinnati, OH 45240.

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