



**International
Standard**

ISO 12103-1

**Road vehicles — Test contaminants
for filter evaluation —**

**Part 1:
Arizona test dust**

*Véhicules routiers — Poussière pour l'essai des filtres —
Partie 1: Poussière d'essai d'Arizona*

**Third edition
2024-01**

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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Test dust description	1
5 Test dust designation	2
6 Particle size distribution	2
7 Chemical composition	2
7.1 Typical chemical content of ISO specified Arizona test dusts.....	2
7.2 Chemical analysis methodology — X-ray fluorescence analysis (XRF).....	3
Annex A (normative) Analysis equipment and operating procedure	4
Annex B (informative) History of Arizona test dust	8
Annex C (informative) Handling and preparation	10
Bibliography	15

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids*.

This third edition cancels and replaces the second edition (ISO 12103-1:2016), which has been technically revised.

The main changes are as follows:

- A0 (0 to 5) μm test dust was added.

A list of all parts in the ISO 12103 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document specifies five grades of test dusts made from Arizona desert sand composed of naturally occurring compounds which motor vehicles are commonly subjected to. These test dusts are used to determine performance of filtration systems. Due to the abrasive characteristics of these materials, they have also been used in wear studies involving bearings, internal combustion engines and fuel injection systems, seals, fan blades, windshield wipers, etc.

This document specifies particle size distribution of five grades of test dust by volume percent as opposed to number characterization.

Dusts complying with volume distribution specified in this document are not appropriate for calibration of particle counters. For this purpose, refer to ISO 11171.

This is an Arizona test dust standard, not other region document. Other dusts and documents can be brought forward to the committee to be developed into a standard.

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Road vehicles — Test contaminants for filter evaluation —

Part 1: Arizona test dust

1 Scope

This document defines particle size distribution and chemical content limits involving five grades of test dust made from Arizona desert sand.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Test dust description

ISO test dusts according to this document are manufactured from Arizona desert sand. Arizona desert sand is a naturally occurring contaminant consisting primarily of silicon dioxide with smaller amounts of other compounds. It is collected from the Salt River area of Arizona desert and sized to specific particle size. Refer to [Annex B](#) for the history of Arizona test dust and to [Annex C](#) for the proper handling of the material.

Arizona desert sand has also been referred to as Arizona road dust, Arizona test dust, Arizona silica, AC fine or coarse test dust, and SAE fine or coarse test dust.

Bulk density of ISO test dusts made from Arizona sand varies with particle size (see [Table 1](#)).

Table 1 — Bulk density

Category	Approximate bulk density, kg/m ³
ISO (0 to 5) µm	500
ISO ultrafine	500
ISO fine	900
ISO medium	1 025
ISO coarse	1 200

5 Test dust designation

Arizona test dusts are available in five standard grades designated as follows:

- ISO 12103-1, A0 (0 to 5) µm test dust;
- ISO 12103-1, A1 ultrafine test dust;
- ISO 12103-1, A2 fine test dust;
- ISO 12103-1, A3 medium test dust;
- ISO 12103-1, A4 coarse test dust.

6 Particle size distribution

Particle size distribution is determined using a light scattering particle size analyser, as referenced in ISO 13320.

[Table 2](#) specifies cumulative volume particle size limits for ISO test dusts made from Arizona desert sand, when determined using a Microtrac Model S3500™¹⁾ particle size analyser per [Annex A](#).

When the different type analyser is employed by a test laboratory, the laboratory should generate suitable correlation data between the analyser by which these powders are supplied to conform [Microtrac¹ analyser] and by the analyser adopted by the test laboratory.

Table 2 — Particle size distributions (volume % less than)

Size, micrometre	A0 (0 to 5) µm	A1 ultrafine	A2 fine	A3 medium	A4 coarse
352,00	—	—	—	—	100,0
248,90	—	—	—	100,0	99,0 to 100,0
176,00	—	—	100,0	99,0 to 100,0	97,2 to 98,2
124,50	—	—	99,0 to 100,0	97,2 to 98,6	93,0 to 94,0
88,00	—	—	97,9 to 98,9	94,7 to 96,0	85,0 to 86,5
44,00	—	—	89,5 to 91,5	82,0 to 83,5	58,0 to 60,0
22,00	100,0	100,0	73,5 to 76,0	62,5 to 64,5	36,0 to 38,5
11,00	98,9 to 99,3	95,5 to 97,5	57,0 to 59,5	42,3 to 43,6	21,0 to 23,0
5,50	90,3 – 92,7	65,0 – 69,0	39,5 – 42,5	22,1 – 23,2	11,5 – 12,5
2,75	57,9 – 61,8	23,0 – 27,0	21,3 – 23,3	10,3 – 11,1	5,5 – 6,3
1,38	20,5 – 23,0	7,0 – 10,0	8,0 – 9,5	3,8 – 4,4	1,8 – 2,1
0,97	11,0 – 12,6	3,0 – 5,0	4,5 – 5,5	2,0 – 2,4	0,74 – 0,83

NOTE Data shown per [Table 2](#) was determined using the particle size analysis instrument indicated in [Annex A](#). Use of any other particle size analysis equipment will obtain different results.

7 Chemical composition

7.1 Typical chemical content of ISO specified Arizona test dusts

See [Table 3](#).

1) Microtrac and Microtrac Model S3500 are trademarks. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

Table 3 — Chemical content

Element	Percentage of mass
Silicon	69,0 to 77,0
Aluminium	8,0 to 14,0
Iron	4,0 to 7,0
Potassium	2,0 to 5,0
Calcium	2,5 to 5,5
Sodium	1,0 to 4,0
Magnesium	1,0 to 2,0
Titanium	0,0 to 1,0

7.2 Chemical analysis methodology — X-ray fluorescence analysis (XRF)

Chemical analysis is performed using an X-ray fluorescence analyser per ASTM C114-15.

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Annex A (normative)

Analysis equipment and operating procedure

A.1 Particle size analyser

A.1.1 General

Particle size data of ISO specified Arizona test dusts as shown in [Table 2](#), were determined using a Microtrac Model S3500™ light scattering type analyser. Use of any other particle size analysis equipment will obtain different results. Other particle size analysis instruments may be acceptable for analysis of test dust products specified in this document, if suitability and correlation is determined between the Microtrac Model S3500™ and the other analyser. Use of particle size analysis instruments other than the Microtrac Model S3500™ will require a modified particle size analysis procedure.

The Microtrac Model S3500™ employs use of three light scattering lasers that are combined to produce the resulting particle size distribution data. A tri-laser system uses precise angular measurement of scattered light through a full 180° angular range with three lasers and two detector arrays. Analysis of scattered light to determine particle size employs a Mie based unified angular scattering theory with a dynamic range of 0,02 µm to 2 800 µm (see [Table A.1](#)).

Normally, it is not acceptable to publish a manufacturer's name or equipment identification. However, due to the close tolerance of the specified particle size limits and variation between instruments by multiple manufacturers, one particle size analysis instrument was defined for this specification.

Particle size distribution specified limits shown in [Table 2](#) were derived from sample analysis of PTI manufactured test dust produced prior to May 1994 using three separate Microtrac Model S3500™ light scattering analysers.

Table A.1 — Microtrac Model S3500™ specifications

Item	Specification
Measuring range	0,02 µm to 2 800 µm
Basic range	Wet 0,7 µm to 1 000 µm
High range	Wet 2,75 µm to 2 800 µm
Standard range	Wet 0,24 µm to 1 400 µm
Special range	Wet 0,086 µm to 1 400 µm
Extended range	Wet 0,021 µm to 2 000 µm
Enhanced range	Wet 0,021 µm to 2 800 µm
Precision	Spherical glass beads D50 = 642 µm, Precision as CV = 0,7 Spherical glass beads D50 = 56 µm, Precision as CV = 1,0 % Spherical latex beads D50 = 0,4 µm, Precision as CV = 0,6 %
Lasers	Wavelength 780 nm

Table A.1 (continued)

Item	Specification
Power	3 mW nominal
Detection system	Two fixed photo-electric detectors with logarithmically spaced segments placed at correct angles for optimal scattered light detection. 0,02° to 163° using 151 detector segments.
Data handling	Volume, number and area distributions as well as percentile and other summary data. Data are stored in ODBC format in encrypted Microsoft Access™ Databases to ensure compatibility with external statistical software applications. Data integrity may be ensured using FDA 21 CFR Part 11 compliant security features including password protection, electronic signatures and assignable permissions.

A.1.2 Microtrac Model S3500™ particle size analysis procedure

A.1.2.1 Sample preparation

Typical sample preparation is as follows.

- a) It is important to ensure the sample taken is representative of the lot of test dust to be tested and mixed well before placing into a clean 20 ml to 50 ml sample vial.
- b) Obtain a clean vial and add the required representative sample quantity based on [Table A.2](#).

Table A.2 — Microtrac Model S3500™ sample weights

ISO grade	Sample amount in mg
ISO 0 to 5	8 to 10
ISO ultrafine	14 to 16
ISO fine	29 to 31
ISO medium	39 to 41
ISO coarse	54 to 56

- c) Add one drop of dispersant to the vial. It is very important that dispersant used does not create bubbles.
- d) Add approximately 10 ml distilled water to the vial and mix by gently moving the vial in a circular motion. Avoid creating bubbles.
- e) Place sample vial and contents in an external low power ultrasonic bath, having a water depth of 2 cm, for 30 s. The ultrasonic bath should be in the range of 50 W to 100 W, 50 kHz to 80 kHz. Do not use the Microtrac internal ultrasonic as it may cause bubbles.

A.1.2.2 Analyser software sample set-up

Analyser software sample set-up is done as follows.

- a) Open the Microtrac FLEX software program.
- b) Click “Measure” on the main program window and select S3500/S3000.
- c) Click “File” and select “Open Measurement Database”, select appropriate database for the material being analysed.
- d) Click “SOP” (Standard Operating Procedure) icon on the measure toolbar. Click Options button to setup appropriate measurement setup parameters. Set measurement parameters per the followings:
 - 1) Timing tab is set as follows:
 - set zero time = 30 s;

ISO 12103-1:2024(en)

- run time = 30 s;
 - number of runs = 3.
- 2) Identifier tab is used to enter general information if desired.
- 3) Analysis tab is set using the following tabs:
- i) Particle information tab:
 - I) select refractive index of 1,51 and save with the appropriate particle name.
 - II) particle characteristics box:
 - set transparency; transparent;
 - set shape; irregular.
 - ii) Fluid information tab:
 - select fluid; water;
 - select refractive index; 1,333.
 - iii) Analysis options tab:
 - select S3000 from Analysis Mode drop down list;
 - select enabled standard from filter drop down list.
 - iv) Sample loading tab is used to enter user defined loading index limits for each grade per [Table A.3](#).

Table A.3 — Microtrac Model S3500™ loading index limits

ISO grade	Loading index limits
ISO (0 to 5) µm	0,90 to 0,91
ISO ultrafine	0,89 to 0,90
ISO fine	0,86 to 0,87
ISO medium	0,86 to 0,87
ISO coarse	0,87 to 0,88

- v) Perspective tab is set as follows:
- select Geom 4 root from progression drop down list;
 - select volume from the distribution drop down list.
- vi) SDC tab is set as follows:
- I) SDC options; Set the following parameters:
 - number of rinses = 3;
 - number of deaerate cycles = 3;
 - flow = 55.
 - II) click OK button when all parameters have been entered.

III) enter appropriate name in the SOP name to save or delete box on the measurement SOP dialogue box and then click the save button.

- e) Open the identifiers (ID) tab. Set the identifiers per the following:
 - 1) enter material description in the title section, i.e. ISO 12103-1, A2 fine test dust.
 - 2) enter ID in first line of sample ID section.
- f) Click “Flow” icon on SDC/ASVR toolbar on the right side of the measurement window to start the recirculator.
- g) Click “S/Z” (set zero) icon on the measure toolbar. After the set zero is successfully completed, the time will appear on the upper left portion of the screen highlighted in green.
- h) Click the “Load Sample” (LD) icon on the measure toolbar.

A.1.2.3 Sample loading and analysis

Obtain a clean pipette and load prepared sample into recirculator making sure the entire sample is loaded without creating bubbles. The indicator bar shall be within the transmission range (green zone) when the entire sample has been loaded. If excess sample has been loaded abort the procedure, rinse recirculator and start over.

Operate icons per the following.

- Click “Run” icon on the measurement bar.
- Click the print icon when sample run is completed.

A.2 Instrument calibration

The Microtrac Model S3500™ analyser cannot be calibrated by the user, but National Institute of Standards and Technology traceable glass powder sold by the manufacturer can be used to verify the analyser is working correctly. Analysis of NIST traceable glass beads should be performed at least every six months.

A secondary calibration material shall be used to verify the analyser is operating correctly. Analysis of the secondary calibration material shall immediately follow analysis of the batch of test dust analysed. Secondary calibration material used shall be from a prior batch of the same grade of test dust being analysed.

Annex B (informative)

History of Arizona test dust

During the 1930s, air intake cleaning devices became widely used by engine manufacturers for use in reducing particulates ingested by internal combustion engines. By 1940, the SAE Journal indicated a need for a standardized test contaminant to evaluate performance of air cleaner systems. The 1943 edition of the SAE Handbook recommends collecting test dust by placing canvas cloth on the ground behind tractors or implements in the Salt River Valley, Arizona, USA.

During following years, a more controlled method of producing large volumes of test dust was required. As a result, the AC Spark Plug Company, division of General Motors Corporation, devised a method of manufacturing test dust by ball milling Arizona desert sand. Two grades of test dust were produced to the following particle size specification given in [Table B.1](#), as published in former SAE J726 Air Cleaner Test Standard, and analysed for particle size using a Roller^{TM2)} analyser.

Table B.1 — Particle size distribution by mass %

Size, micrometre	Fine grade	Coarse grade
0 – 5	39 ± 2	12 ± 2
5 – 10	18 ± 3	12 ± 3
10 – 20	16 ± 3	14 ± 3
20 – 40	18 ± 3	23 ± 3
40 – 80	9 ± 3	30 ± 3
80 – 200	—	9 ± 3

In 1979, AC Spark Plug began using a Leeds and Northrup MicrotracTM laser diffraction particle size analyser, in place of the RollerTM analyser, to determine particle size distributions of AC Fine and Coarse Test Dusts. AC indicated that considerable correlation testing between the L and N MicrotracTM and RollerTM analysers was performed and in 1982 requested that SAE subcommittees revise fine and coarse test dust particle size specifications per [Table B.2](#).

**Table B.2 — Particle size distribution by volume
(as measured with an L and N MicrotracTM analyser)**

Size, micrometre	Fine grade	Coarse grade
5,5	38 ± 3	13 ± 3
11	54 ± 3	24 ± 3
22	71 ± 3	37 ± 3
44	89 ± 3	56 ± 3
88	97 ± 3	84 ± 3
176	100	100

2) Roller is a trademark. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

ISO 12103-1:2024(en)

AC Rochester (formerly AC Spark Plug Company) ceased production of AC fine and coarse test dusts in August 1992. ACTM fine³⁾ and ACTM coarse⁴⁾ were also referred to as air cleaner fine (ACFTD) and air cleaner coarse (ACCTD). These dusts were ball mill processed and are no longer available.

During 1981, Powder Technology, Inc. (PTI) began formulating test contaminants for the filtration and aerospace industries. PTI used a Coulter Counter TAI^{TM5)} analyser to determine particle size of test dusts. The published specification during 1982 for standardized fine and coarse Arizona test dusts was the RollerTM table shown previously as [Table B.1](#).

PTI originally produced SAE fine and coarse test dusts according to the distributions listed per [Table B.1](#) using the Coulter Counter TAITM analyser as a means of size measurement.

The Coulter Counter TAITM instrument originally used by Powder Technology, Inc. became obsolete and was replaced with a Coulter Multisizer IIe^{TM6)} analyser May 1994. Particle size designation of ISO test dusts described in ISO 12103-1:1997 reflect Coulter Multisizer IIeTM correlation data derived from analysis of samples of PTI manufactured test dusts produced prior to May 1994. ISO 12103-1:1997 provided cumulative volume particle size limits in [Table B.3](#).

Table B.3 — Particle size distribution as measured by Coulter Multisizer IIeTM

Size, micro-metre	ISO 12103-1:1997, A1 ultrafine (% less than)	ISO 12103-1:1997, A2 fine (% less than)	ISO 12103-1:1997, A3 medium (% less than)	ISO 12103-1:1997, A4 coarse (% less than)
1	1,0 to 3,0	2,5 to 3,5	1,0 to 3,0	0,6 to 1,0
2	9,0 to 13,0	10,5 to 12,5	4,0 to 5,5	2,2 to 3,7
3	21,0 to 27,0	18,5 to 22,0	7,5 to 9,5	4,2 to 6,0
4	36,0 to 44,0	25,5 to 29,5	10,5 to 13,0	6,2 to 8,2
5	56,0 to 64,0	31,0 to 36,0	15,0 to 19,0	8,0 to 10,5
7	83,0 to 88,0	41,0 to 46,0	28,0 to 33,0	12,0 to 14,5
10	97,0 to 100	50,0 to 54,0	40,0 to 45,0	17,0 to 22,0
20	100	70,0 to 74,0	65,0 to 69,0	32,0 to 36,0
40	—	88,0 to 91,0	84,0 to 88,0	57,0 to 61,0
80	—	99,5 to 100	99,0 to 100	87,5 to 89,5
120	—	100	100	97,0 to 98,0
180	—	—	—	99,5 to 100
200	—	—	—	100

ISO test dusts according to this document are produced by a dry jet milling process. Particle size distributions are not identical to former dusts produced by AC Rochester Corporation, a division of GM. Therefore, efficiency and dust capacity of filters tested with this document test dusts may deviate from results obtained with former dusts.

Revision of the first edition of this document proposed by PTI in 2010 was approved by ISO committee members because the Coulter Multisizer IIeTM became obsolete and its replacement with a Microtrac Model S3500TM was judged to be rational. The proposed particle size limits in [Table 2](#) were determined by multiple analyses of historical samples used to determine the particle size limits specified in ISO 12103-1:1997.

3) AC fine is a trademark. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

4) AC coarse is a trademark. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

5) Coulter Counter TAI is a trademark. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

6) Coulter Multisizer IIe is a trademark. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

Annex C (informative)

Handling and preparation

C.1 Preparation prior to use

Care should be taken in preparation of test dusts because stratification or agglomeration of particles may occur during shipping and handling. Stratification of particles involves formation of layers of particles of differing sizes within a vessel containing test dust. Stratification is caused by natural migration of particles propelled by vibration during handling or storage. Although no documented scientific studies have been conducted relative to stratification of Arizona test dust particles, it is possible that coarse particles migrate to the top and fine particles concentrate near the bottom of storage containers. Therefore, it is recommended that test dusts be mixed or rebled immediately preceding use.

Test dusts may retain or absorb moisture during the manufacturing process or in storage. Moisture content of test dusts is not considered significant relative to many types of testing involving these materials. However, sensitive or closely controlled test programs may require that test dust be dried in an oven prior to use.

C.2 Health hazards in handling test dusts

Health hazards are identified by the following causes and effects.

- a) **eye contact:** (acute/chronic) exposure to airborne dust may cause immediate or delayed irritation or inflammation of the cornea;
- b) **inhalation:** (chronic) inhalation exposure to free silica may cause delayed lung injury, including silicosis, a disabling and potentially fatal lung disease, and/or cause or aggravate other lung diseases or conditions;
- c) **skin contact:** this material contains sodium oxide and calcium oxide, which may be harmful or irritating to skin;
- d) **ingestion:** no adverse effects;
- e) **carcinogenic potential:** this material contains respirable crystalline silica (quartz). Crystalline silica (quartz) inhaled from occupational sources is classified as carcinogenic to humans.

NOTE Potential health effects can vary depending upon the duration and degree of exposure.

C.3 First aid measures

First aid measures should be taken per the following:

- a) **eyes:** immediately flush eye thoroughly with water. Get medical attention if irritation persists;
- b) **skin:** wash with soap and water. Seek medical attention if irritation persists;
- c) **inhalation:** remove person to fresh air. if breathing is difficult, administer oxygen. if not breathing, give artificial respiration. Seek medical help if coughing and other symptoms do not subside;
- d) **ingestion:** do not induce vomiting. If conscious, have the victim drink plenty of water and call a physician if discomfort is experienced.

C.4 Fire-fighting measures

Fire-fighting measures are not necessary because of the following descriptions:

- a) **flash point:** N/A;
- b) **auto ignition temperature:** not combustible;
- c) **flammable limits:** N/A;
- d) **lower explosive limit:** none;
- e) **upper explosive limit:** none;
- f) **special fire-fighting procedures:** none;
- g) **extinguishing media:** not combustible;
- h) **unusual fire and explosion hazards:** none;
- i) **hazardous combustion products:** none.

C.5 Accidental release measures

Accidental release measures should be taken per the following:

- a) **respiratory protection:** use local exhaust or general dilution ventilation to control dust levels below applicable exposure limits. Minimize dispersal of dust into the air. Use appropriate approved respiratory protection for respirable crystalline silica;
- b) **eye protection:** wear safety glasses with side shields or goggles to avoid contact with the eyes. In extremely dusty environments and unpredictable environments, wear tight-fitting unvented or indirectly vented goggles to avoid eye irritation or injury;
- c) **methods for cleanup:** use a vacuum or other appropriate cleaning device that does not generate airborne dust.

C.6 Handling and storage

Handling and storage should be done per the following:

- a) **handling:** use adequate ventilation and dust collection;
- b) **storage:** store in a manner so that airborne dust does not exceed applicable exposure limits. Store material in a closed container.

C.7 Exposure controls/personal protection

Exposure controls and personal protection should be done per the following:

- a) **local exhaust ventilation:** use sufficient local exhaust ventilation to reduce the level of airborne respirable crystalline silica;
- b) **respiratory protection:** use appropriate, approved respiratory protection for respirable crystalline silica;
- c) **hand protection:** hand protection is not needed, as the material does not pose a health risk to skin;
- d) **eye protection:** wear safety glasses with side shields or goggles to avoid contact with the eyes. In extremely dusty environments and unpredictable environments, wear tight-fitting unvented or indirectly vented goggles to avoid eye irritation or injury;