

National Personal Protective Technology Laboratory

Silica Exposures in the US

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What is Silica Dust?

- **Silica dust contains Quartz, also known as crystalline silica**
- **Quartz is a very pure compound**
 - 46.7% silica, 53.3% oxygen
- **Tridymite and Cristobalite**
 - Chemically identical
 - Different crystalline forms, from high temperature

History of Silica Related Disease

- **1672, van Diemerbroeck**
 - Cutting into a stonecutter’s lung “like cutting into a mass of sand”
- **1713, Ramazzini**
 - Describes asthma and consumption in stonecutters due to dust exposure
- **1800s, Johnstone, Thackrah, Holland**

History Continued

- **1831, England**
 - Stonemasons usually die before 40
- **1843, England**
 - 30% of grinders have “grinder’s asthma”
- **1950 to 1964**
 - 27,000 “pneumoconiosis” cases in 18 US states

History – Twentieth Century

- **The prevalence of silicosis in the 1920's was severe**
 - Initial focus of prevention was on reducing gross exposure
 - Total mass concentration measurements were used

Epidemiologic Studies in US

- **Public Health Service (PHS) and Bureau of Mines (BOM), 1913 -1915**
 - 60.4% of hard rock miners had lung disease
- **Harrington and Lanza, 1916-1919**
 - 42.4% disease rate in copper miners
- **Dreesen et al, 1939**
 - 10% silicosis in mine workers

The Modern Era

- **Flinn et. Al., 1958-1961**
 - 50 metal mines, 14,000 miners
 - Interviews, X-rays, pulmonary function testing
 - 476 miners (3.4%) with silicosis based on x-ray

Flinn Pottery Worker Data

TABLE III-2

RELATION OF DUST CONCENTRATION AND LENGTH OF EMPLOYMENT
IN THE POTTERY INDUSTRY TO SILICOSIS*

Dust concentration, million particles/cu ft	Years in pottery industry				
	0-9	10-19	20-29	30-39	Over 40
0-3.9:					
Cases of silicosis - - - - -	-	1	1	-	-
Workers exposed - - - - -	481	223	65	21	8
Percentage - - - - -	0	0.4	1.5	0	0
4-7.9:					
Cases of silicosis - - - - -	1	6	26	27	29
Workers exposed - - - - -	321	198	110	53	34
Percentage - - - - -	0.3	3	24	51	85
8-15.9:					
Cases of silicosis - - - - -	-	8	5	10	10
Workers exposed - - - - -	176	119	25	17	14
Percentage - - - - -	0	7	20	59	71
Over 16:					
Cases of silicosis - - - - -	13	33	10	5	4
Workers exposed - - - - -	363	174	21	7	5
Percentage - - - - -	4	19	48	71	80

*Includes 1st, 2nd, and 3rd stage cases

Vermont Granite Shed Data

- **Data on stone cutting operations in Vermont**
- **Vermont put dust controls in place in the granite cutting “sheds”**
- **Dust controls significantly reduced lung disease**
- **Disease was related to exposure concentration and years of exposure**
- **Studies conducted by the Public Health Service, Russell, Ashe and Bergstrom over a 30 year period**

Beginning of Regulation by Occupational Safety and Health Administration

TABLE III-1

EMPLOYMENT IN INDUSTRIES HAVING POTENTIAL EXPOSURE TO
FREE SILICA, 1970

Metal mining	76,000
Coal mining	125,000
Nonmetallic minerals, except fuels	95,000
Stone, clay, and glass products	507,000
Iron and steel foundries	188,000
Nonferrous foundries	69,000
Total	<u>1,060,000</u>

US Regulation

- **Adopted from existing Federal contract regulations in 1972**
- **The Occupational Safety and Health Act of 1970 extended coverage to all US industry**
 - Based on the existing American National Standards Institute (ANSI) mineral dust standard
 - Standard is known as 29 Code of Federal Regulations 1910.1000 Z3 Mineral Dusts

Z3 Tables

Substance	Million Particles Per cubic foot (MMPCF)	mg/m ³ Respirable dust	mg/m ³ Total dust
Quartz (Respirable fraction)	<u>250</u> %SiO ₂ +5	<u>10 mg/m³</u> %SiO ₂ +2	
Quartz (Total Dust)			<u>30 mg/m³</u> %SiO ₂ +2
At 50% quartz		0.2 mg/m ³	0.6 mg/m ³
At 2% quartz		2.5 mg/m ³	7.5 mg/m ³

Additional Z3 table information

- **Cristobalite: Use $\frac{1}{2}$ the value calculated from the count or mass formula for quartz.**
- **Tridymite: Use $\frac{1}{2}$ the value calculated from the formula for quartz.**
- **Amorphous silica: very liberal limit, 15 mg/m³**
- **Conversion factor**
 - mppcf X 35.3 = million particles per cubic meter = particles per c.c.

NIOSH R.E.L.

- **0.05 mg/m³ (TWA for up to 10-hour workday during 40-hr week)**
- **Established 1974**
- **Quartz, cristobalite, and tridymite as respirable dust**

R.E.L (Recommended Exposure Limit)

Measurement Issues

- The percent quartz in dust samples is always important

Percent Quartz	Maximum allowable exposure
50% quartz	0.2 mg/m³
2% quartz	2.5 mg/m³
<1% quartz	5mg/m³

Measurement Issues

- The size of the particles is important
- An industrial hygienist must determine the size distribution
- Respirable dust goes into the lungs, larger particles are more likely to be captured in the nose and throat.
- Total dust should not exceed 15 mg/m³

% respirable dust	Maximum allowable Exposure
20% quartz With 50% respirable	1 mg/m³
20% quartz With 10% respirable	5 mg/m³
20% quartz With 0% respirable	15 mg/m³ (15 mg/m³ is the total dust limit)

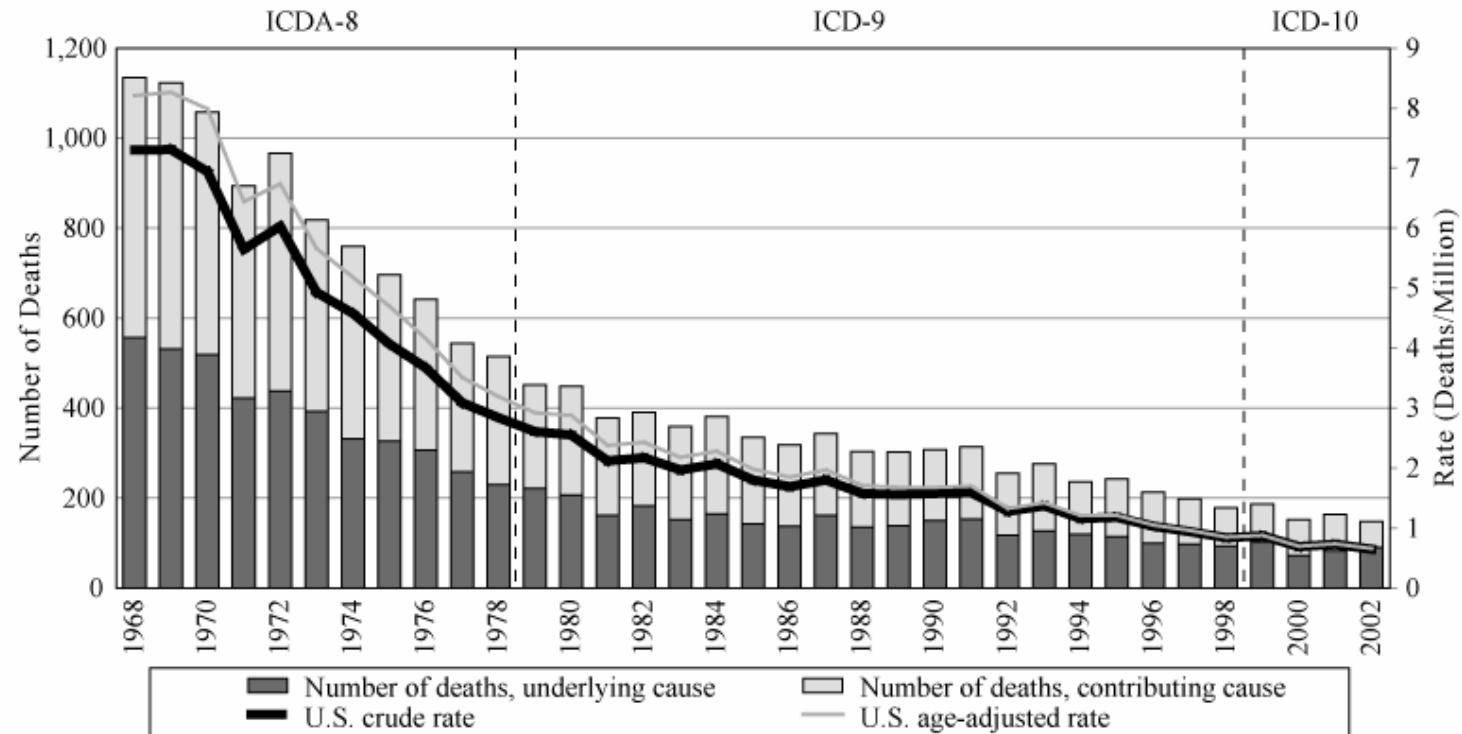
Has The US Standard Worked?

Work-Related Lung Disease (WoRLD) Surveillance System

Table of Contents > Silicosis and Related Exposures > Silicosis: Mortality > 2005F03-01

Silicosis: Mortality

Silicosis: Number of deaths, crude and age-adjusted death rates, U.S. residents age 15 and over, 1968–2002



Note: Slight variations in numbers may exist when compared to previous WoRLD Surveillance Reports. See appendices for source description, methods, and ICD codes.

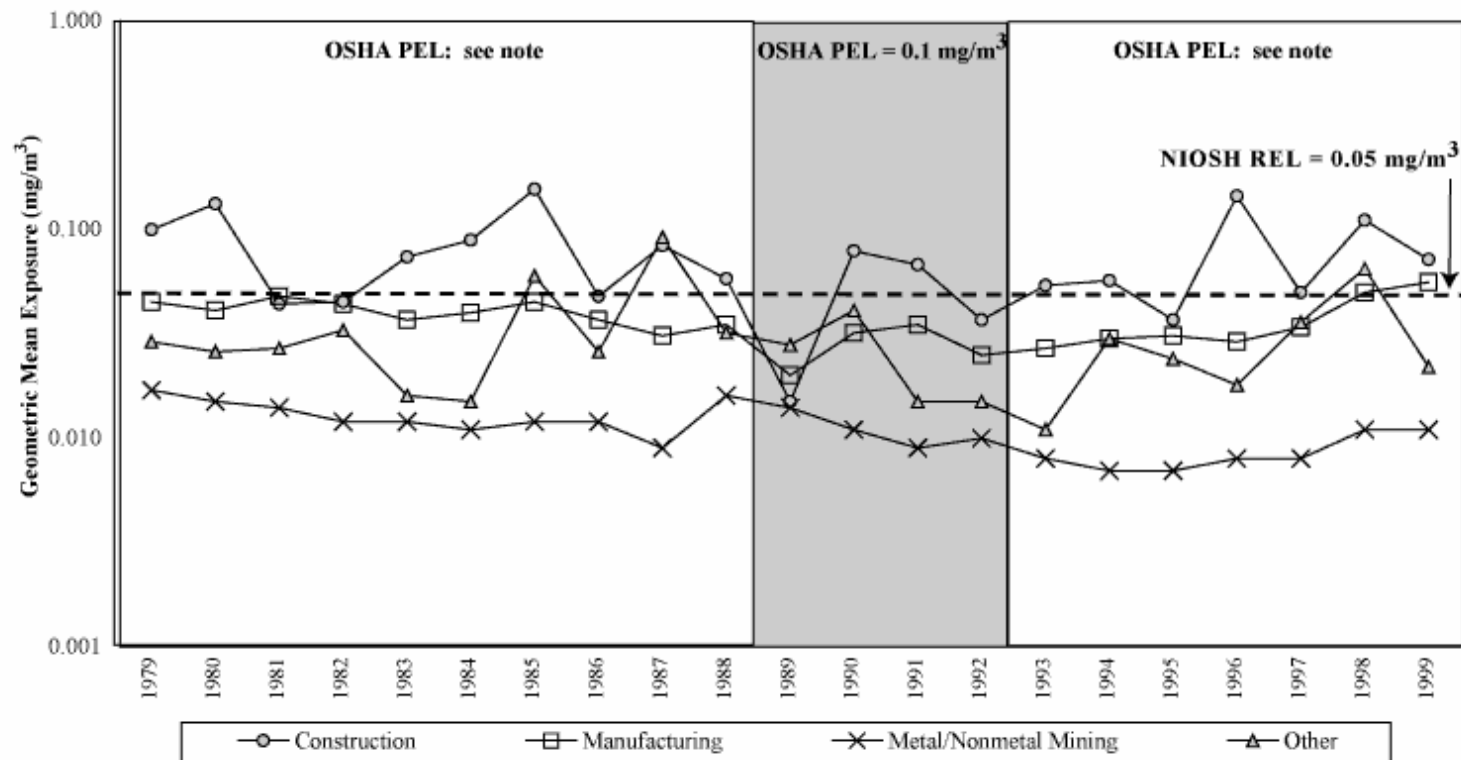
Source: National Center for Health Statistics multiple cause-of-death data. Population estimates from U.S. Bureau of the Census.

Continued Silicosis Exposures

- 200 to 300 silicosis related deaths were reported each year during the period 1992-1995.
- Further, the number of silicosis-related deaths among persons aged 15 to 44 did not decline substantially during 1968-1994, accounting for 207 of the 14,824 silicosis-related deaths during this period
- More work to reduce silicosis deaths and disease in the US is needed
 - Health Effects of Occupational Exposure to Respirable Crystalline Silica. DHHS (NIOSH) Publication No. 2002-129
April 2002

Silicosis: Respirable Quartz Exposures

Respirable quartz: Geometric mean exposures by major industry division, MSHA and OSHA samples, 1979–1999



La reducción en la mortalidad por silicosis en los EEUU 1968-2002

Silicosis Mortality Decline in U.S. 1968-2002

- **Implementation of national standards in 1970s**
- **Ancillary prevention (e.g., respiratory protection)**
- **Declining employment in heavy industries (e.g., mining industry)**
- **Sin embargo, la sobreexposición a sílice está extendida** However, U.S. “silica overexposure remains widespread”
 - Se necesitan vigilancia e intervención
Surveillance and interventions needed

Source: CDC/NIOSH MMWR April 29, 2005

<http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5416a2.htm>

NIOSH CONCLUSIONES: Salud Health

- **Con las normas actuales de los EEUU o los límites recomendados de exposición (REL) de NIOSH, existe todavía una estimación de riesgo importante de silicosis crónica durante el trabajo de toda una vida.**

There is a significant estimated risk* of chronic silicosis over working lifetime at the current U.S. standards or NIOSH REL.

***Es decir, hay más de un caso de silicosis radiográfica por cada 100 trabajadores si durante 40 o 45 años de trabajo tienen exposiciones de $\sim 100 \mu\text{g}/\text{m}^3$ o $\sim 50 \mu\text{g}/\text{m}^3$**

i.e., \geq one case of radiographic silicosis per 100 workers at cumulative exposure over 40- or 45- year working lifetime at $\sim 100 \mu\text{g}/\text{m}^3$ or $\sim 50 \mu\text{g}/\text{m}^3$

Conclusions-Health-cont'.

- **Occupational exposure to respirable crystalline silica is also associated with:**
 - **Cáncer pulmonar Lung cancer**
 - **Enfermedades de la vía respiratoria
Airways diseases (i.e., bronchitis, emphysema, COPD)**
 - **Infecciones micobacteriales y micóticas Mycobacterial and Fungal
Infections**
(e.g., Pulmonary tuberculosis (TB))

How is Silica Dust Exposure Controlled in the US?

OSHA Hierarchy of Controls

- **To achieve compliance with paragraphs (a) through (d) of this section,**
 - administrative or engineering controls must first be determined and implemented whenever feasible.
 - When such controls are not feasible to achieve full compliance, protective equipment or any other protective measures shall be used to keep the exposure of employees to air contaminants within the limits prescribed in this section.

- **OSHA 29 CFR1910.1000e**

OSHA Ventilation Standard

- **OSHA ventilation standards**
- **29 CFR 1910.94**
 - 1910.94 (a) and (b) include specific instructions on exhaust requirements for
 - Abrasive grinding
 - Polishing

Conclusiones: exposición, monitoreo, y controles de ingeniería

CONCLUSIONS: Exposure, Monitoring, & Engineering Controls

- Hay que mejorar los métodos de análisis y la toma de muestras para medir concentraciones inferiores del REL.

Improved sampling and analytical methods needed to measure accurately below NIOSH REL.

- Si no es posible implementar controles de ingeniería, se necesitan otras medidas de protección. Engineering controls may not be feasible; may need other worker protection measures (e.g., substitution, respirator use).
- Many U.S. occupational exposures still exceed standards.

Communicating the Risks and the Solutions

- **OSHA has excellent etools**

- <http://www.osha.gov/SLTC/etools/silica/index.htm>
- <http://www.osha.gov/SLTC/silicacrystalline/index.html>

- **NIOSH also offers a number of guides**

- <http://www.cdc.gov/niosh/topics/silica/>
- <http://www.cdc.gov/niosh/silfact1.html>

Sample from the OSHA Silica Topics

- **Silica Crystalline: Quartz - Analytical Methodologies**. OSHA, (2003). Reviews analytical methods for silica.
- **OSHA Technical Manual (OTM)**. OSHA Directive TED 01-00-015 [TED 1-0.15A], (1999, January 20).
- **Sampling for Special Analyses**. Includes sampling information for crystalline silica.
- **Sample Shipping and Handling**. Contains sample handling, packaging, and shipping

NIOSH Habla Espanol

- **NIOSH has resources available in Spanish**
- **Examples**
 - <http://www.cdc.gov/spanish/niosh>
 - <http://www.cdc.gov/spanish/niosh/pubs-sp.html#hh>

La Prevención de Silicosis

- **¿Qué es Silicosis?** La silicosis es una enfermedad pulmonar causada por sobreexposición a la sílice cristalina respirable. Es irreversible y puede causar invalidez física o la muerte. La sílice es el segundo mineral más abundante en la corteza terrestre y es un componente mayor de arena, piedra, y minerales metalíferos. La sobreexposición al polvo que contiene partículas de sílice cristalina puede causar la formación de tejidos de cicatrización en los pulmones. Eso disminuye la capacidad de los pulmones de extraer oxígeno del aire que respiramos. El divertirse o jugar en una playa de arena no constituye un riesgo de silicosis. Más de un millón de trabajadores en los EE.UU. han estado expuestos a la sílice cristalina. Cada año, más de 250 trabajadores estadounidenses mueren con silicosis. No existe ninguna cura para esta enfermedad, pero es 100% evitable si los patrones, trabajadores, y profesionales de la salud colaboran para reducir las exposiciones. Además de silicosis, la inhalación de partículas de sílice cristalina ha sido asociada con otras enfermedades, como bronquitis y tuberculosis. Algunos estudios indican también una asociación con cáncer pulmonar.

Using Respirators to Reduce Silicosis

- **Respirators may be a useful tool in reducing silica exposures**
- **First: administrative or engineering controls must first be determined and implemented whenever feasible**
- **Respirators must be used properly by trained workers to be effective**

Using Respirators to Reduce Silicosis

- **Respirator use requires compliance with a respiratory protection program to be effective**
- **Follow the hierarchy of controls**
- **Select the correct respirators**
- **Train workers**
 - How to wear respirator
 - Need for a fit test
 - How to sanitize and maintain respirator

Disclaimer: The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

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