National Industrial Sand Association

Silicosis Prevention Program

Seven Steps To Eliminating Silicosis

Among Industrial Sand Workers

Note to User

This guide is not intended to satisfy or to be a substitute for the safety and health requirements of Federal, State, or Local regulatory agencies. Appropriate regulations and laws should be consulted and followed. The program described in this guide has been developed to meet the specific needs and challenges of the industrial sand industry in preventing silicosis among industrial sand workers. It is not intended to be an occupational health program for exposure to crystalline silica in other industries, since parts of this program may not be well suited to other industries and elements of an appropriate program specifically aimed at another industry may not be included in this program.

The scope of this guide is to outline the seven steps set forth in the National Industrial Sand Association's (NISA) Silicosis Prevention Program to eliminate silicosis among its workforce. It does not address in detail the seven steps involved in the total program, but aims to give explanation to the seven steps that can be put in place by management to eliminate silicosis. NISA has prepared for its member companies other information sources and conducted training on silicosis prevention to include dust sampling, medical surveillance, engineering controls, respiratory protection, and other measures which supplement this guide.

More importantly, the elements outlined in this guide must not be considered a total occupational health program. Other stresses such as noise, heat, radiation, non-silica-bearing dusts, chemical contaminants, and other site-specific conditions, although obvious elements of a total occupational health program, are beyond the intended coverage of this program.

To obtain more comprehensive information relative to the National Industrial Sand Association's Silicosis Prevention Program, please contact:

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Preface

Silicosis is an incurable and completely preventable occupational lung disease caused by prolonged overexposures to dust containing respirable crystalline silica. According to the most recent statistics by the National Institute for Occupational Safety & Health (NIOSH), more than 100 people living in the United States die each year with silicosis. Others inflicted with the disease can experience breathing difficulties and a reduced quality of life. Because of the potential for exposure to silica containing dust in the mining and processing of industrial sands, those within the industry need to understand what the disease is and how it can be prevented.

The objective of this guide is to provide NISA member companies with guidance on the practical implementation of the NISA Silicosis Prevention Program (SPP). The NISA SPP contains seven (7) specific steps which, if implemented, can successfully result in the management of worker exposure to silica containing dust and the prevention of silicosis. This guide is not intended to cover all aspects of a comprehensive silicosis prevention program, but to provide an overview of the NISA SPP and how it may be practically implemented.

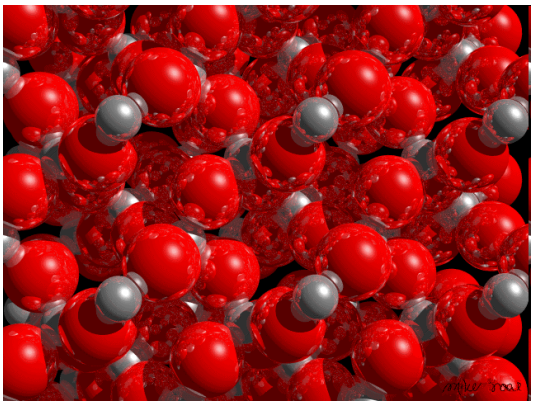
The NISA Silicosis Prevention Program consists of the following seven elements:

- ◊ Management Commitment to Implementation;
- ◊ Occupation Health Program Implementation;
- ◊ Medical Surveillance;
- ◊ Dust Exposure Assessment;
- ◊ Dust Control;
- ◊ Employee Involvement; and
- ◊ Smoking Cessation Program.

NISA expects all member companies to implement and manage a comprehensive Silicosis Prevention Program at all worksites sufficient to eliminate silicosis among its employees.

What is Silica?

Silica is the name given to a group of minerals composed of silicon and oxygen, the two most abundant elements in the earth's crust. Silica is found commonly in the crystalline state and rarely in an amorphous state. It is composed of one atom of silicon and two atoms of oxygen resulting in the chemical formula SiO_2. Silica exists in nine different crystalline forms or polymorphs with the three main forms being quartz, which is by far the most common, tridymite and cristobalite.



Quartz is the second most common mineral in the earth's crust. It is found in all three of the earth's rock types - igneous, metamorphic and sedimentary. It is particularly prevalent in sedimentary rocks since it is resistant to physical and chemical breakdown by the weathering process. Since it is so abundant, quartz is present in nearly all mining operations. It is present in the host rock, in the ore being mined, as well as in the soil and surface materials above the bedrock, which are called the overburden. Besides quartz, the only other form of crystalline silica that finds commercial use is cristobalite. Quartz and diatomaceous earth, an amorphous form of silica, may be converted to cristobalite in a rotary kiln at high temperature, with the assistance of a catalyst.

What is Respirable Crystalline Silica?

Respirable dust refers to those dust particles that, when inhaled, are small enough to reach deep into the lungs. Because crystalline silica, as quartz, is a major constituent of rocks, minerals and soils, practically all dust clouds contain some percentage of respirable quartz. When the particle size range of the dust is sufficiently small (such that the particles fall within the respirable fraction), the dust will travel deep into the lungs. It is at this point that respirable crystalline silica can cause health effects.

Occupational Exposure to Crystalline Silica in Industrial Sand Facilities

Mining related exposures to respirable crystalline silica typically occur during mining operations and within processing plants. Many of the mineral beneficiation processes have the potential to expose workers to airborne respirable crystalline silica. Additionally, some mineral beneficiation processes, like milling and drying, decrease particle size and moisture, increasing the likelihood of respirable crystalline becoming airborne and potentially inhaled.

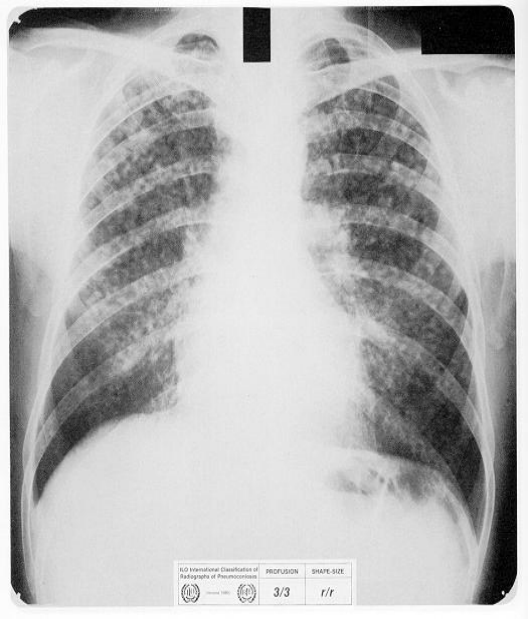
Health Effects of Respirable Crystalline Silica Exposure

Exposure to airborne respirable crystalline silica remains a significant occupational hazard encountered by industrial sand workers. The primary health risk is silicosis, caused by the prolonged inhalation of respirable crystalline silica dust. Studies have also identified lung cancer as a potential disease associated with occupational exposure to respirable crystalline silica. Other studies have linked exposure to respirable crystalline silica with the increased risk of developing autoimmune disorders, diseases affecting the kidneys, tuberculosis, and other non-malignant respiratory diseases. The recognition, evaluation, and control of exposures to respirable crystalline silica have long been of concern to the occupational health profession and to NISA.

Silicosis

Silicosis is an irreversible occupational lung disease caused by prolonged overexposure to respirable crystalline silica; it may be disabling, and it is sometimes fatal. Overexposure to dust that contains microscopic particles of crystalline silica can cause scar tissue (pulmonary fibrosis) to form in the lungs, which reduces the lungs ability to exchange carbon dioxide with oxygen from the air we breathe.

There are three types of silicosis depending upon the airborne concentrations of respirable crystalline silica and the duration of exposure:



- Chronic silicosis is the most common type of silicosis. It results in scarring (pulmonary fibrosis) in the lungs and occurs after many years, usually 10–30, of breathing too much respirable crystalline silica dust..
- Accelerated silicosis results from breathing in very high concentrations of respirable crystalline silica dust over a relatively short period (5-10 years), whereas chronic silicosis may take as many as 10-30 years to develop.
- Acute silicosis is the most destructive and serious type of silicosis and develops from breathing in extremely high concentrations of respirable crystalline silica dust over a period ranging from as little as a few weeks to 5 years.

Although silicosis can be debilitating, many individuals with the disease lead normal lives with little or no physical impairment. However, since there is no specific treatment for silicosis, it is essential that NISA member companies focus on silicosis prevention. In individuals diagnosed with silicosis, it is important to prevent disease progression by removing the source of silica exposure.

Silica and Cancer Risk

Numerous internationally recognized groups have determined that exposure to respirable crystalline silica in occupational settings is a potential carcinogen. These conclusions were drawn on the basis of a relatively large number of human population studies that together provide sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica. In many (although not all) of these studies, lung cancer risks were elevated and could not be explained by other factors. Recent reviews have tended to conclude that if exposures are controlled to prevent silicosis, they will probably also prevent cancer.

Occupational Exposure Limits

MSHA adopted an exposure limit for crystalline silica in surface metal and nonmetal mines from the 1973 Threshold Limit Values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) OSHA adopted a PEL for crystalline silica as quartz in general industry that pertains to the regulation of industrial sand in manufacturing operations from the 1968 TLVs. TLVs refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In 1974, NIOSH established a recommended exposure limit of 0.05 mg/m3 as a 10-hour TWA for respirable crystalline silica to prevent the risk of silicosis from occupational exposure. In 2005, the ACGIH revised its current crystalline silica exposure limit by adopting a TLV of 0.025 mg/m3 for all three common forms of crystalline silica (quartz, cristobalite, and tridymite).

The MSHA and OSHA exposure limit for respirable dust that contains quartz, expressed in milligrams per cubic meter, is determined from the following formula:

$$\text{Quartz PEL} = 10 \div (\%\ \text{Quartz} + 2)$$

Because the PEL is applied to respirable dust containing quartz, the concentration of quartz is limited to approximately 0.1 mg/m^3. Table 1 on the following page provides U.S. limits and guidelines for occupational exposure to crystalline silica and respirable dust containing crystalline silica.

Reference	Substance	Guideline or Limit (mg/m3)
MSHA	Respirable dust containing quartz in underground surface metal and nonmetal mines	PEL = 10 ÷ % quartz + 2 (8-hr TWA)
OSHA	Respirable dust containing silica, quartz Respirable dust containing silica, cristobalite Respirable dust containing silica, tridymite	PEL = 10 ÷ % quartz + 2 (8-hr TWA) PEL = half of value calculated from the formula for quartz (8-hr TWA) PEL = half of value calculated from the formula for quartz (8hr TWA)
NIOSH	Respirable crystalline silica	REL = 0.05 (for up to a 10-hr workday during a 40-hr workweek)
ACGIH	Respirable crystalline silica: α-Quartz Cristobalite	 TLV = 0.025 (8-hr TWA) TLV = 0.025 (8-hr TWA)

Table 1. U.S. limits and guidelines for occupational exposure to crystalline silica and respirable dust containing crystalline silica.

Seven Steps to Eliminating Silicosis

The following seven steps, implemented in whole or in part, can potentially reduce and/or eliminate the risk of the development of silicosis amongst NISA member employees. NISA member companies who have fully committed to the NISA SPP have demonstrated substantial reductions in the incidence of silicosis among their employees. While implementation of all seven steps of the SPP by the full NISA membership is the ultimate goal of NISA, the two most critical elements of the SPP are chest X-rays and dust exposure assessment. NISA member companies who commit to at least these two specific elements gain the honor of hanging the NISA SPP plaque within their workplace. The hanging of this plaque communicates to employees, visitors, and regulators that the employer is strongly committed to the prevention of silicosis.

Management Commitment to Implementation

One of the most important elements of the NISA SPP is NISA member company management voluntary commitment to implementation of the NISA SPP. Commitment to the NISA SPP permits committed companies to proudly hang the official NISA SPP plaque on their walls for employees, visitors, and customers to see. It is a sign of commitment to the prevention of one of the longest known occupational diseases. In order to commit to the NISA SPP and be recognized by NISA for their participation, a company must agree to implement, at a minimum, chest X-rays and dust exposure assessment. This commitment requires not only implementation of these elements, but

the sharing of disease and dust exposure assessment data with the NISA membership during annual NISA benchmarking sessions.

Occupational Health Program (OHP) Implementation

The purpose of the medical surveillance program outlined in the NISA OHP manual is to prescribe baseline and periodic health evaluations for workers exposed to crystalline silica. The guidance in the NISA OHP and in this abbreviated guide have been modeled after authoritative medical organizations such as the American Thoracic Society (ATS), the American College of Occupational and Environmental Medicine (ACOEM), the National Kidney Foundation, and the ASTM Standard Practice for Health Requirements Relating to Occupational Exposure to Respirable Crystalline Silica. The unabbreviated NISA OHP should be provided as guidance to physicians and allied health professionals who conduct medical surveillance for member company employees.

Medical Surveillance

The medical surveillance program has the following objectives:

1. Establish a baseline from which to assess changes that may develop in the individual at a future date. Thus, each worker serves as his or her own control, and the ability to recognize early change is greatly enhanced.
2. Detect abnormalities that might be consistent with the health effects of silica exposure at an early stage, when intervention can lead to the prevention of disease progression.
3. Prevent the development of silicosis that could produce pulmonary impairment in the worker.
4. Prevent the development of other occupational conditions that might be associated with exposure to silica.
5. Disclose to the worker occupationally and non-occupationally related abnormalities for appropriate medical follow-up.
6. Develop data on which epidemiological studies of crystalline silica exposure can be based.

The primary focus of the medical surveillance program is early detection of silicosis. However, studies have identified an increased risk to tuberculosis (TB) for those exposed to silica, particularly to those with 25 or more years of exposure to respirable crystalline silica. Additionally, more recent studies have identified a possible association between silica exposure and kidney disease, and given that kidney diseases are suitable for screening and early detection, some components have been included in the NISA medical

surveillance program to assess kidney function, and to gather information on potential risk factors for kidney disease. The medical surveillance program for silica exposure consists of the following components:

1. A medical history that focuses on the presence of respiratory symptoms, smoking habits, and risk factors for kidney disease.
2. A comprehensive occupational history that details prior exposure to potentially harmful dusts, chemicals, and other physical agents. Any adverse effects related to these exposures must be recorded.
3. A physical examination to assess the general condition and respiratory status of the worker.
4. A 14-by-17-inch posterior anterior (PA) chest X-ray, preferably obtained using a high kilovoltage technique. For silicosis and other pneumoconioses, films should be interpreted by qualified board-certified radiologists who are NIOSH-certified B readers. Films should be classified in accordance with the *2000 Guidelines for the Use of ILO International Classification of Radiographs of Pneumoconioses*. In addition to accepting conventional chest X-rays, the NISA OHP program will accept good quality digital chest images reproduced on film to be used with the current ILO system for classification of the pneumoconioses.
5. Pulmonary function tests that include spirometric measurements of forced expiratory volume in one second (FEV1) and forced vital capacity (FVC). Such tests should be performed, calculated, and interpreted in accordance with the ATS 1994 Update Standardization of Spirometry and the 2005 ATS-European Respiratory Society ERS Standardization of Spirometry guidelines.
6. Because workers with silicosis are at an increased risk of developing tuberculosis (TB), the baseline tuberculin skin test reactivity status of workers should be established. Early inactive tuberculosis infection can be detected using two kinds of tests: the tuberculin skin test (TST) or a QuantiFERON blood test (QF test). Either the QuantiFERON-TB Gold test or the QuantiFERON-TB Gold In-Tube test is acceptable.
7. Because of the high risk that untreated inactive or latent TB infection (LTBI) could progress, early detection by periodic testing for LTBI should be performed annually in those with X-ray evidence of silicosis (1/0 or greater profusion category using the ILO classification). Periodic testing should also be considered for those with more than 25 years of silica exposure but without evidence of silicosis.
8. The National Kidney Foundation recommends three basic tests to screen for kidney disease: a quantitative test for protein or albumin in the urine (proteinuria), a calculation of glomerular filtration rate (GFR) based on a serum creatinine measurement, and a blood pressure measurement.

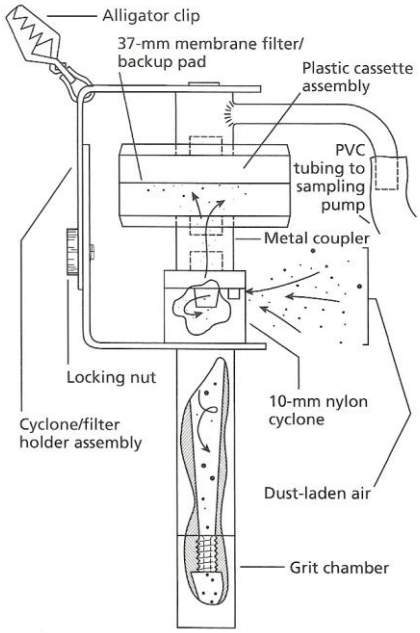
Recordkeeping and Worker Notification – All medical records obtained on workers should be retained for at least 30 years after the worker ceases employment. This is necessary because of the chronic nature and long latency of silicosis, and because the records may also be useful in assessing the adequacy of occupational standards. The

worker should be provided a copy of the examination results, and evidence that this has been done should be obtained.

Frequency of Examinations – Two types of examinations are included in the medical surveillance program. The first is baseline examinations which should be completed to establish a baseline on the worker's respiratory health status prior to exposure to silica. The examination should include, as a minimum, a medical history, including a respiratory symptom questionnaire and smoking history; a complete occupational and job history; a medical evaluation of the thorax, as indicated; a PA chest X-ray; spirometry, tuberculin testing, and any additional tests ordered by the company or examining physician. The second is periodic examinations. With the exception of chest X-rays, medical evaluations should be administered at least every 2 years and should be comprehensive examinations that include the elements of the baseline examination. The frequency of X-ray examinations depends on the number of years since first exposure to silica dust, the age of the worker, and whether any signs or symptoms are present. Details regarding the recommended frequency for chest X-rays can be found in the NISA OHP Manual.

Dust Exposure Assessment

The primary purpose of dust sampling is to characterize the environment in the breathing zone of individual workers to evaluate their work exposure. Breathing zone samples, also referred to as personal samples, are collected within a few inches of the worker's nose to determine the amount of respirable dust the worker inhales during the workday. Worker dust exposure assessments can be used for comparison with the MSHA PEL (or other regulatory exposure limits) for quartz and as a measure of dose in epidemiological studies; other reasons include evaluating the effectiveness of engineering controls, changes in dust levels as a result of process changes, and the selection and adequacy of personal protective devices such as respirators.



In some situations area sampling is conducted by placing samplers at strategic locations in the workplace to measure concentrations of dust in the general workplace air. In other situations, personal data real-time aerosol monitor (PDR) sampling is conducted by affixing the instrument to an individual or by placing instruments at strategic locations in the workplace. However, personal samples in the breathing zone of the worker are the most important exposure measurement to be taken in the assessment of silica exposures.

It is crucial that NISA member companies implement and manage a silica exposure program to collect personal breathing samples from all employees exposed to industrial

sand so that periodic measurements of silica exposure and cumulative exposure assessments can be made. The results of these measurements should be used for:

- Comparison to an exposure limit (i.e. MSHA, OSHA, NIOSH, or ACGIH).
- To identify peak exposures related to tasks to determine where implementation of engineering controls can be most effective in reducing overall worker exposure.
- To identify changes in dust exposure that might result from changes in a process or operation.
- To sample pre- and post-engineering control measure to determine the efficiency obtained by the control device.
- To use in proper selection of personal protective equipment such as respirators.
- To determine cumulative and other exposure metrics for use in health studies.

The level of airborne dust present at any given work site depends on several factors: the type of task being performed and how that task is being performed; the physical (wet or dry) state of the material being handled, the size of the particulates, and the nature and location of the work site, (for example, an enclosed or open space). The airborne dust to which the industrial sand worker is exposed is generally considered to be in one of two classes:

1. Respirable particulates that are small enough to be inhaled into the deep lung (generally less than 10 micrometers in diameter).
2. Non-respirable particles that are too large to be respirable and generally do not enter the deep lung region.

Dust Control

The purpose of this element is to control dust exposures through the use of engineering, personal protection and administrative controls. The control of hazards from exposures to respirable crystalline silica and the elimination of silicosis is **the primary and single most important** reason for developing a comprehensive silicosis prevention program. There is little point to dust sampling, medical surveillance, training or any other program component if the results of those efforts do not prompt necessary controls measures. In other words, if this program element fails to control hazardous dust exposures the silicosis prevention program is a failure.

Dust controls encompass any device, equipment or procedure that, in some way, reduces or eliminates a hazardous crystalline silica exposure. Every work environment is unique so the most effective controls (singularly and combined) are often those designed specifically for the space, machinery, process flow, work schedule and other variables that differ from one work environment to the next.

NISA member companies are to undertake a program to anticipate, evaluate and control hazardous dust exposures and to continually monitor the effectiveness of control strategies.

Industrial hygienists and occupational health professionals often refer to a "hierarchy" of controls in the workplace. In its basic form, this hierarchy (in order of desirability) is described as elimination/substitution, engineering controls, administrative controls and personal protective equipment (PPE). Before silica control measures can take place, proper recognition, evaluation and assessment of sources of dust exposure must be completed. The data collected and analyzed in dust assessment step is critical to the recognition and evaluation of exposures requiring control and in determining which types of control measures should be employed and assigning priorities to engineering controls requiring capital investment. Comprehensive dust control measures generally involve the use of a number of available strategies.

Employee Involvement in Silicosis Prevention

Employee involvement provides the means through which workers develop and express their own commitments to safety and health, for both themselves and their fellow workers. "Worker involvement" is how workers take part in making decisions about health and safety where they work. A workforce fully involved in health and safety management, and a system of workers operating in partnership with management, are essential parts of an effective health and safety program. Workers in the quarry or on the processing plant floor spend the most time and know the most about the jobs and tasks that they do, so they are in the best position to help managers understand sources of dust exposures and help implement effective controls. Group decisions have the advantage of the group's wider range of experience, and workers are more likely to support and use solutions in which they have had input.

NISA member companies should create opportunities for workers to become involved in the administration of the Silicosis Prevention Program. Of course, management is ultimately responsible for providing a safe and healthy workplace; however, worker involvement has contributed significantly to the success of many health and safety programs.

There are three steps toward achieving worker involvement.

- Providing information, instruction and training to help employees become informed about how to work safely and protect their health.
- Engaging workers through a genuine exchange of views regarding worker health and safety. This does not take away the right of managers to manage – they must still make the final decision – but it does mean that employees will be asked for their views and that these will be considered before decisions regarding health and safety are taken.
- Full involvement in health and safety where workers and employers trust each other and work together to manage health and safety. This goes further than simply consulting with workers. It means agreeing to solve problems together.

Examples of worker involvement include:

- Participation on joint worker-management committees;
- Participation in health and safety inspections;
- Participation in hazard assessment of dust;
- Assistance in preparation of work practices to minimize dust exposures;
- Training of current and newly hired workers;
- Providing presentations at safety and health committee; and
- Reporting operations and processes needing dust evaluation and upset conditions with existing controls.

Smoking Cessation

It is widely known and reported by all leading public health organizations that tobacco use contributes to an extensive list of serious diseases, including cardiovascular and cerebrovascular diseases, multiple cancers, emphysema, and bronchitis; and second-hand smoke contributes to pediatric illness. The Centers for Disease Control and Prevention (CDC) reports tobacco use is responsible for:

- At least $96 billion per year in direct medical costs and
- An estimated $96.8 billion per year in lost productivity due to sickness and premature death

The two major purposes of tobacco cessation programs in the workplace are encouraging tobacco users to quit, and reducing employees' exposure to second-hand smoke. Tobacco-free workplace policies and decreasing the numbers of employees who model tobacco-use behavior will also reduce tobacco use initiation among employees and, in addition, may influence tobacco-use behavior in employees' families. Nicotine addiction is often severe and may require multiple attempts to quit before the tobacco user can quit permanently. Health benefits should be structured to provide support for multiple attempts to quit.

The objective of this element is to reduce the added impact of smoking on the health effects of silica exposure. NISA member companies are expected to implement and administer smoking-cessation policies for its employees. A good starting point can be found on a CDC website at:
http://www.cdc.gov/workplacehealthpromotion/implementation/topics/tobacco-use.html