Good Practice Guide on Workers Health Protection through the Good Handling and Use of Crystalline Silica and Products containing it

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Preamble

1. Why this guide

This guide is the result of an assembly of existing knowledge and information within sectors, which produce and/or use products or raw materials containing crystalline silica about the management of respirable crystalline silica. The publication of this guide is a contribution of the industry (employers and employees) towards the protection of workers from possible exposure to respirable crystalline silica in the workplace.

2. Objective of this Good Practice Guide

The objective of this guide is to give producers and users of products and materials that contain crystalline silica guidance on the practical application of a programme to manage respirable crystalline silica and guidance on the safe use of crystalline silica containing products in the workplace.

The silica producing and using industries stress that employees should be protected against potential health effects caused by occupational exposure to respirable crystalline silica in the workplace. Therefore efforts should be focused on minimising potential personal exposure to respirable crystalline silica in the workplace.

This is a dynamic guide, which concentrates on the aspects that are considered the most significant. Although comprehensive, it has not been possible to cover in detail all areas of concern. Users, customers, workers, and readers are advised to consult occupational health professionals and other experts concerning all matters regarding control of respirable crystalline silica in each specific workplace.

This Good Practice Guide is an Annex to the Agreement on Workers Health Protection Through the Good Handling and Use of Crystalline Silica and Products Containing it, based on certain principles: The Parties agree that crystalline silica and materials / products / raw materials containing crystalline silica are, as further described in Annex 5 hereto, basic, useful and often indispensable components / ingredients for a large number of industrial and other professional activities contributing to protecting jobs, and securing the economic future of the sectors and companies, and that their production and wide-range use should therefore continue

Note to users

This guide represents a summary of information collected from a number of sources, including existing documents providing information on the respirable crystalline silica issue, legal documents and expertise of people working in the industry.

In this short document it is not possible to cover all of the topics mentioned comprehensively, nor is it possible to cover in detail all areas of concern regarding respirable crystalline silica in the workplace. Users, customers, workers, and readers are advised to consult occupational health professionals and other experts concerning all matters regarding control of respirable crystalline silica in each specific workplace.

Part 1: Respirable crystalline silica essentials.

1. Introduction

Crystalline silica is an essential component of materials which have an abundance of uses in industry and are a vital component in many things used in our everyday lives. It is impossible to imagine houses without bricks, mortar or windows, cars without engines or windscreens, or life without roads or other transport infrastructures, and everyday items made of glass or pottery.

For many years, it has been known that the inhalation of fine dust containing a proportion of crystalline silica can cause lung damage (silicosis). In fact, silicosis is the world's oldest known occupational disease. However, the health risks associated with exposure to crystalline silica dust can be controlled and, by using appropriate measures, reduced or eliminated completely. It is just a matter of assessing the risk and taking appropriate action.

The first part of this Good Practice Guide is aimed primarily at employers. It is designed to help them decide whether the health of their employees, or others present in the workplace, is at risk from exposure to respirable crystalline silica. This booklet will guide them through the process of risk assessment and provide them with some general guidance on methods for controlling exposure to respirable crystalline silica in the workplace. It also stresses the importance of continual improvement.

At the end of Part 1, there is a glossary, which defines some of the more technical terms that are used in the document.

The second part of this guide is aimed at both employers and those who actually work with materials containing crystalline silica. It provides detailed guidance on methods for safe production, handling and use of these materials.

1.1 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. In spite of its simple chemical formula, SiO_2, silica exists in many different forms. Silica is found commonly in the crystalline state but occurs also in an amorphous (non-crystalline) state. Crystalline silica is hard, chemically inert and has a high melting point. These are prized qualities in various industrial uses.

This Good Practices Guide only covers three of the different forms of crystalline silica, i.e. the minerals quartz, cristobalite and tridymite. It does not cover amorphous silica, fused silica or other silicate minerals. Quartz, cristobalite and tridymite are often referred to as types of "free" crystalline silica because the crystalline silica is not chemically combined.

Quartz is by far the most common form of crystalline silica. It is the second most common mineral on the earth's surface and it is found in almost every type of rock i.e. igneous, metamorphic and sedimentary. Since it is so abundant, quartz is present in nearly all mining operations. Irrespective of industrial activities, respirable crystalline silica is present in the environment.

Cristobalite and tridymite are not abundant in nature. However they are found in some igneous rocks. In industrial circumstances, cristobalite is also obtained when quartz is heated (to temperatures in excess of 1400°C), for example during the production and use of refractory materials. Cristobalite is also formed when amorphous silica or vitreous silica is heated at high temperature.

1.2 Respirable crystalline silica

Not all dust is the same! For any kind of dust, there are different particle sizes, often referred to as dust fractions. When dust is inhaled, its point of deposition within the human respiratory system is very much dependent upon the range of particle sizes present in the dust.

Three dust fractions are of main concern: the inhalable, thoracic and respirable dust fractions, which are defined in the European standard EN481. Information on this standard is given in section 3.1. In the case of crystalline silica, it is the respirable fraction of the dust that is of concern for its health effects.

Respirable dust can penetrate deep into the lungs. The body's natural defence mechanisms may eliminate much of the respirable dust inhaled. However, in case of prolonged exposure to excessive levels of this dust, it becomes difficult to clear the respirable dust from the lungs and an accumulation of dust can, in the long term, lead to irreversible health effects. Due to the fact that the health effects of crystalline silica are related to the respirable dust fraction, this Good Practices Guide will focus on the control of respirable crystalline silica.

1.3 Occupational exposure to respirable crystalline silica

Occupational exposure to respirable crystalline silica can occur in any workplace situation where airborne dust, containing a proportion of respirable crystalline silica, is generated.

Respirable dust particles are so small that they cannot be seen with the naked eye. Once airborne, respirable dust takes a very long time to settle. A single release of dust into the workplace air can lead to significant occupational exposure. In fact, in situations where the air is constantly stirred-up and where no fresh air is being introduced, respirable dust may remain airborne in the workplace for days.

Occupational exposure to respirable crystalline silica occurs in many industries including quarrying, mining, mineral processing (eg drying, grinding, bagging and handling), slate working, stone crushing and dressing, foundry work, brick and tile making, some refractory processes, construction work, including work with stone, concrete, brick and some insulation boards, tunnelling, building restoration and in the pottery and ceramic industries.

2. Silica and the silica industry

2.1 Where silica occurs

Crystalline silica, in the form of the mineral quartz, is found in many different materials – with sandstone being almost pure quartz. Other forms of silica occur but are of little importance occupationally. The table below gives an indication of typical levels of "free" crystalline silica in certain mineral sources, but it must be noted that these figures do vary.

Mineral sources	Percentage of crystalline silica
Ball clay	5 – 50%
Basalt	Up to 5%
Natural Diatomite	5-30%
Dolerite	Up to 15%
Flint	Greater than 90%
Granite	Up to 30%
Gritstone	Greater than 80%
Iron ores	7 – 15%
Limestone	Usually less than 1%
Quartzite	Greater than 95%
Sand	Greater than 90%
Sandstone	Greater than 90%
Shale	40 – 60%
Slate	Up to 40%

Source: HSE brochure, Control of respirable crystalline silica in quarries.

2.2 Activities involving use of crystalline silica containing materials.

Aggregates

Aggregates are a granular material used in construction. Nearly 3 billion tonnes of aggregates are produced and used in Europe annually. However, a majority of operators in the sector are small and medium sized enterprises. A typical small site provides direct employment for 7 to 10 persons. The aggregates industry consists of around 25,000 extraction sites across Europe, with 250,000 employees in the EU.

The most common natural aggregates are sand, gravel and crushed rock with a wide range of free silica content (from 0% to 100%). Subject to the individual risk assessments to be carried out under this Agreement, only the deposits with a high content of silica are relevant. But even in such cases, the risks of Respirable crystalline silica exposure for workers are normally low. Aggregates produced from rocks containing a small percentage of silica are, without prejudice to individual risk assessment, likely to be negligible in terms of their impact on worker's health.

Ceramics industry

The ceramics industry uses silica principally as a structural ingredient of clay bodies and as a major constituent of ceramic glazes. The principal ceramic products containing silica include tableware and ornamental ware, sanitary ware, wall and floor tiles, bricks and roof tiles, refractories etc.

Around 2,000 companies produce ceramics in the EU. The number of employees in the EU ceramics industry is estimated at around 234,000. The ceramic industry is present in virtually all EU Member States.

Foundries

The foundry industry's products are ferrous, steel or non-ferrous metal castings produced by pouring molten metal into moulds which are typically, in total or in parts, made of bonded silica sand. The foundry industry is an important supplier to the automotive industry, mechanical engineering and other industries. It is a branch of mostly small and medium sized companies: roughly 4,000 foundries with 300,000 employees are situated in the EU Member States.

Glass Industry

Silicon dioxide is the principal glass forming oxide and thus silica sand is the major ingredient in all types of glass. The main glass products include packaging glass (bottles, jars etc.), flat glass (for buildings, mirrors, cars, etc.), domestic glass (tableware: drinking glasses, bowls; decoration, etc.), glass fibre (for reinforcement, insulation) and special glass (for tv, laboratory, optics etc.).

More than 1,000 companies produce glass in the EU. The glass industry is present in all European countries and employs more than 230,000 people in the EU.

After melting the raw material, there is no crystalline silica any more. Glass is an amorphous material.

Industrial Minerals and Metalliferrous Minerals industries

Industrial Minerals:

A number of industrial minerals products are composed of silica. Silica is found commonly in the crystalline state but occurs also in an amorphous (non-crystalline) state. Crystalline silica is hard, chemically inert and has a high melting point. These are prized qualities in various industrial uses, mainly in the glass, foundry, construction, ceramic and chemicals industries. 145 million tons of industrial minerals (e.g. bentonite, borate, calcium carbonate, diatomite, feldspar, gypsum, kaolin & plastic clay, talc, etc) are extracted every year in Europe. Although not all do, industrial minerals may contain variable amounts of crystalline silica.

Those industrial minerals are produced by 300 companies or groups operating about 810 mines and quarries and 830 plants in 18 EU Member States, and in Switzerland, Norway, Turkey, Bulgaria, Romania and Croatia. The industrial minerals industry employs about 100,000 persons in the EU.

Metal ores:

A wide range of metal ores are extracted within the EU and for some, such as mercury, silver, lead, tungsten, zinc, chromium, copper, iron, gold, cobalt, bauxite, antimony, manganese, nickel, titanium, the EU is a relatively significant producer. In some cases, the European producers rank amongst the first ten producers in the world.

Metal ores are produced in 12 EU Member States as well as in Norway, Turkey, Bulgaria, Romania, Kosovo and Serbia. In the EU, this section of the mining and minerals industry employs directly about 23,000 people.

Although not all do, metal ores may contain variable amounts of crystalline silica.

Cement Industry

Cement is a powdered substance mainly used as the binding agent in the making of concrete. It is produced through several stages, basically made up of the two following essential phases:

- manufacture of a semi-finished product, so-called "clinker", obtained from the calcination in a high-temperature kiln (1 450°C) of a “raw mix” made up of a mixture of clay, limestone, and several other additives.

- manufacture of cement as a finished product, obtained by the homogeneous mixture of the ground clinker and calcium sulphate (gypsum) with or without - depending on the type of cement - one or more additional components: slag, fly ash, pozzolana, limestone, etc.

In 2004, the cement production of the current 25 Member States of the EU has reached 233 million tons, about 11% of the total world production (2,1 billion tons).

There are nearly 340 plants in the EU. Four of the five largest cement companies in the world are European. The cement industry employs about 55,000 persons in the EU.

Mineral Wool

Mineral wool has a unique range of properties, combining high thermal resistance with long-term stability. It is made from molten glass, stone or slag that is spun into a fibre-like structure which creates a combination of thermal, fire and acoustic properties, essential to the thermal and acoustic insulation as well as to the fire protection of domestic and commercial buildings or industrial facilities.

These properties derive from its structure, a mat of fibres which prevent the movement of air, and from its chemical composition.

Insulation manufacturers are developing to meet the growing environmental concerns of society, improving standards and regulations for the use of insulation materials.

Among mineral wools, only glass wool is of concern with regard to crystalline silica as glass wool is manufactured using sand, whilst stone wool is not. After melting the raw material for glass wool, there is no crystalline silica any more, as it becomes an amorphous material.

The mineral wool industry is present in all European countries and employs over 20,000 people across the EU.

Natural Stone Industry

Dimension stone exists in nature as an almost ready-made building material. Few realize, however, that it takes millions of years for this material to get to the point at which it can be easily produced and processed.

The industry consists only of small and medium sized companies of between 5 to 100 employees and is an essential supplier of the building industry. More than 40,000 companies exist in the EU, employing around 420,000 persons in the EU. Work with natural stones not only covers the production of stone in quarries, much more important is the processing of stones and the implementation of stones. Restoration and high-tech applications need qualified education and training which starts with stone workers up to high-tech stone engineers.

Mortar Industry

Mortar is defined as a mixture of aggregates, generally with a grain size of less than 4 mm (sometimes less than 8 mm, e.g. mortar for special decorative renders or floor screed mortar) and one or more binders and possibly additives and/or added mixtures.

Mortar with inorganic binders contains in addition water. The application and use of mortar is not limited to masonry constructions. The field of floor screed mortar is growing. There are many special kinds of mortar which are used for concrete repair, for tile fixing, for roofs, for the anchoring of bolts and for many other applications.

In addition the external thermal insulating composite systems (ETICS) are also a product of the mortar industry playing an important role in energy saving measures. More than 1,300 companies produce mortar in the EU. The EU mortar industry has more than 34,400 employees.

Precast Concrete Industry

Precast concrete is a factory-made building material widely used worldwide and available in all sizes and forms, from very small paving units to more than 50 meters long bridge elements.

Its production process consists in mixing cement, aggregates, water, additives and admixtures in different proportions, pouring them in moulds and let them harden. The products are supplied to the market in a dust-free hardened state. Dust generation can mainly occur in raw material handling and post-manufacturing mechanical treatments.

The industry is composed of small to medium-size enterprises, spread all over Europe. Estimated figures for the EU are: 10,000 production units, 250,000 workers and 300 to 400 million tons of products.

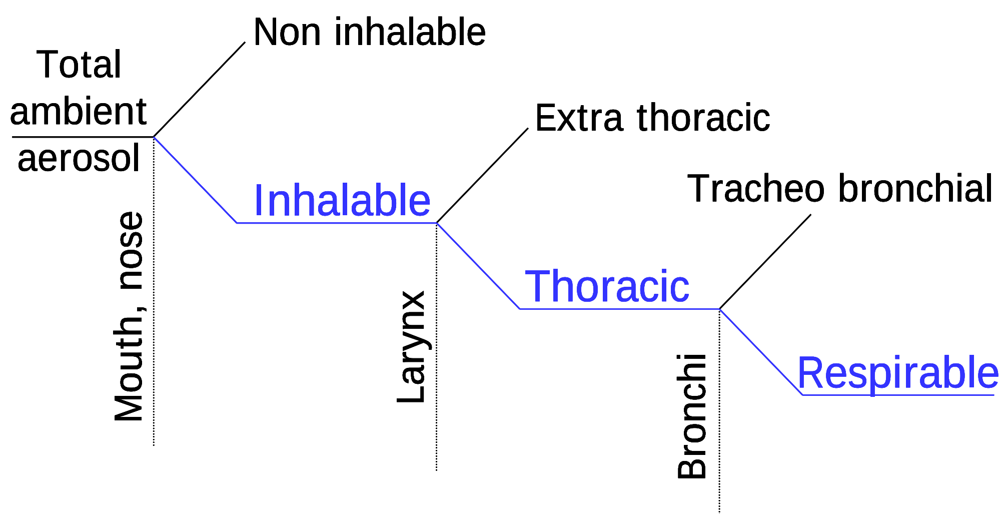
3. Respirable crystalline silica and its health effects

3.1 Respirable crystalline silica

When considering dust, three dust fractions are of main concern: the inhalable, thoracic and respirable dust fractions. However, for crystalline silica, the respirable dust fraction is the most important due to its potential health effects in humans.

It is also important to note that national occupational exposure limit values for crystalline silica apply to the respirable dust fraction. This dust fraction corresponds to the proportion of an airborne contaminant, which penetrates to the pulmonary alveolar (gas exchange) region of the lungs. This fraction normally represents 10 to 20% of the inhalable dust fraction, but the proportion can vary considerably.

The following diagram explains the difference between the various dust fractions:



Source: Dichotomous model of aerosol fractionation according to Görner P. and Fabriès J.F.

The illustration overleaf identifies the different sections of the lung. The larynx (mentioned in the diagram above) lies between the pharynx (upper part of the airway) and the trachea (windpipe). The pulmonary alveolar region is made up of approximately 300 million alveoli, or air sacs.

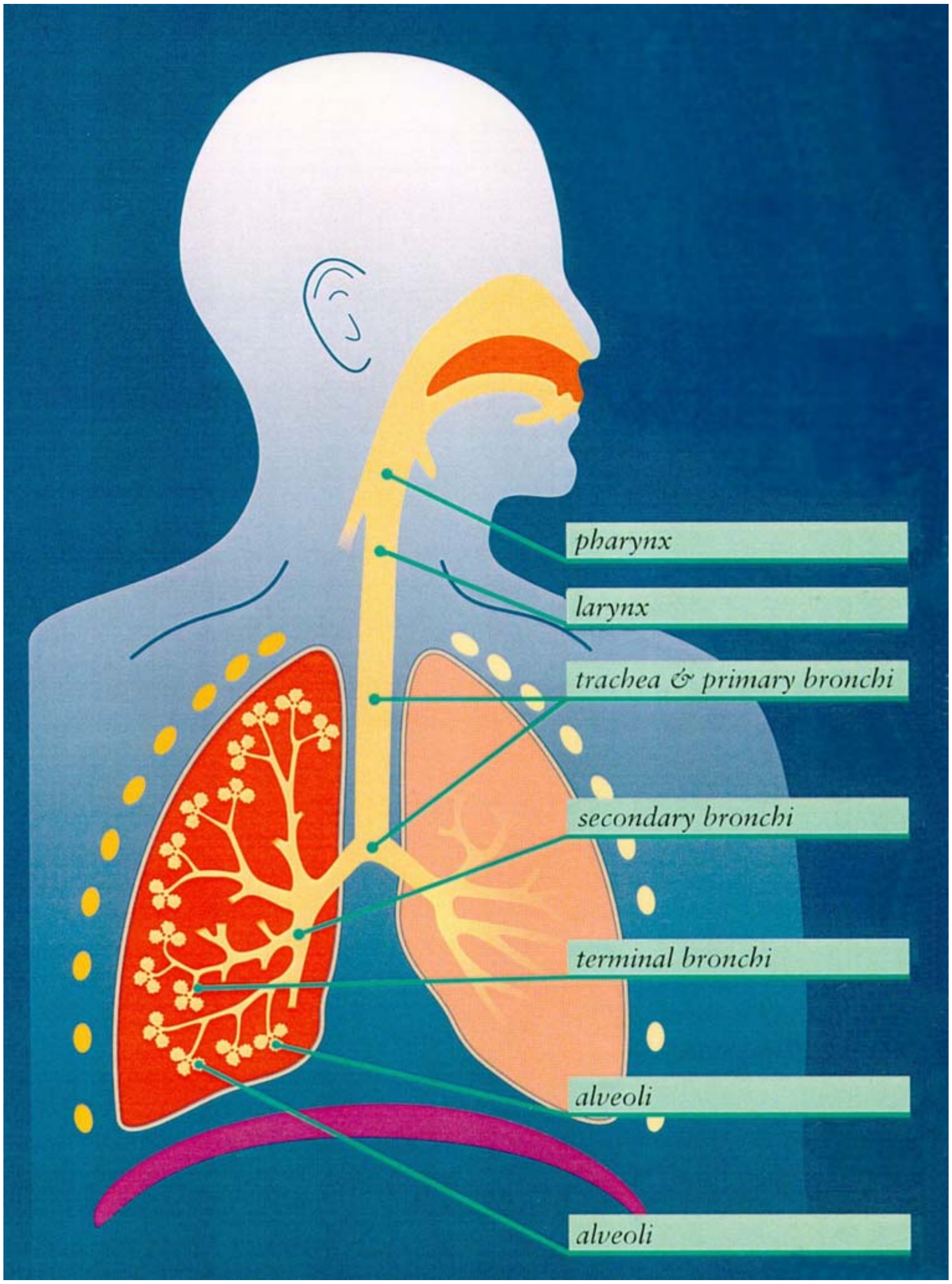
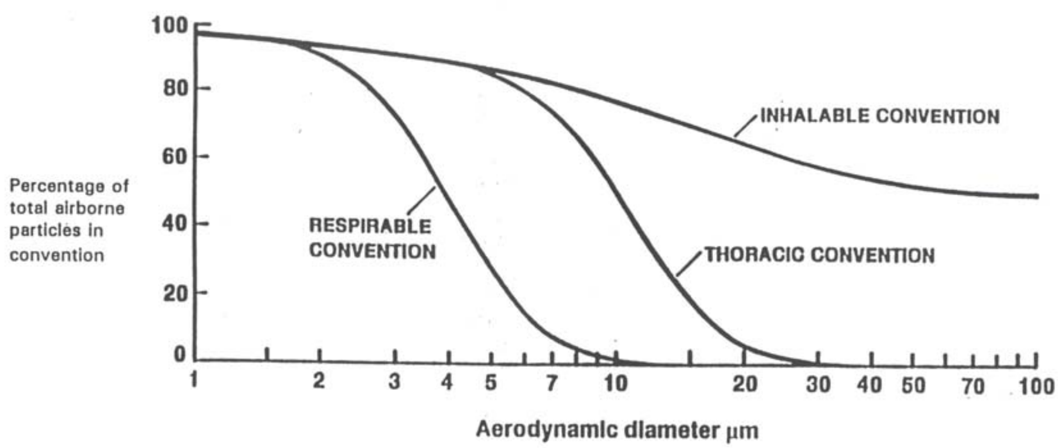


Diagram showing the different parts of the lung.

The European Standards Organisation (CEN) and the International Standards Organisation (ISO) have agreed standardised conventions for the health-related sampling of dusts or aerosols in workplaces (EN 481, ISO 7708).

These conventions represent target specifications for instruments used to assess the possible health effects due to inhalation of aerosols.

The following figure illustrates the sampling conventions:



The inhalable, thoracic and respirable conventions as percentages of total airborne particles, from EN 481.

The graph shows the probability that a particle of a specific aerodynamic diameter will penetrate the different parts of the human respiratory system.

For example, following the respirable convention, there is a 50% chance (or a probability of 0.5) that a particle of aerodynamic diameter 4 µm will penetrate the pulmonary alveolar region of the lung. Similarly, there is a 30% chance (probability of 0.3) that a particle of aerodynamic diameter 5 µm will penetrate this region of the lung.

The following table shows numerical values of the conventions in percentage terms.

As percentage of total airborne particles			
Aerodynamic Diameter µm	**Inhalable Convention %**	**Thoracic Convention %**	**Respirable Convention %**
0	100	100	100
1	97.1	97.1	97.1
2	94.3	94.3	91.4
3	91.7	91.7	73.9
4	89.3	89.0	50.0
5	87.0	85.4	30.0
6	84.9	80.5	16.8
7	82.9	74.2	9.0
8	80.9	66.6	4.8
9	79.1	58.3	2.5
10	77.4	50.0	1.3
11	75.8	42.1	0.7
12	74.3	34.9	0.4
13	72.9	28.6	0.2
14	71.6	23.2	0.2
15	70.3	18.7	0.1
16	69.1	15.0	0
18	67.0	9.5	
20	65.1	5.9	
25	61.2	1.8	
30	58.3	0.6	
35	56.1	0.2	
40	54.5	0.1	
50	52.5	0	
60	51.4		
80	50.4		
100	50.1		

Source: EN 481. Numerical values of the conventions, as percentages of total airborne particles

3.2 Health effects of respirable crystalline silica

People at work are rarely exposed to pure crystalline silica. The dust they breathe in at the workplace is usually composed of a mixture of crystalline silica and other materials.

The response of an individual is likely to depend on:

- the nature (e.g. particle size and surface chemistry) and crystalline silica content of the dust
- the dust fraction
- the extent and nature of personal exposure (duration, frequency and intensity, which may be influenced by the working methods)
- personal physiological characteristics
- smoking habits

Silicosis

Silicosis is a commonly known health hazard, which has been associated historically with the inhalation of silica-containing dust (Fubini 1998).

Silicosis is one of the most common types of pneumoconiosis. It is a nodular progressive fibrosis caused by the deposition in the lungs of fine respirable particles of crystalline silica. The resulting scarring of the innermost parts of the lungs can lead to breathing difficulties and, in some cases, death. Larger (non-respirable) particles are more likely to settle in the main airways of the respiratory system and may be cleared by mucus action (HSE 1998).

Silicosis is one of the world's oldest known occupational diseases and is caused by the inhalation of respirable crystalline silica (Stacey P. 2005).
Silicosis can vary greatly in its severity, from "simple silicosis" to "progressive massive fibrosis". Generally, three types of silicosis are described in literature (EUR 14768; INRS 1997):

- Acute silicosis occurs as a result of extremely high exposure to respirable crystalline silica over a relatively short period of time (within 5 years). The condition causes rapidly progressive breathlessness and death, usually within months of onset
- Accelerated silicosis can develop within 5 to 10 years of exposure to high levels of respirable crystalline silica
- Chronic silicosis is often described as the result of exposure to lower levels of respirable crystalline silica, occurring over longer periods of time (exposure duration greater than 10 years)

Future cases of silicosis can be reduced by implementing appropriate measures to reduce exposure to silica-containing dusts. Such measures include improved work practices, engineering controls, respiratory protective equipment and training programmes.

Silica and cancer risk

In 1997, a working group of the International Agency for Research on Cancer (IARC), which has no regulatory power in the European Union but which is an authority in the field of Cancer Research, concluded on the basis of literature review that inhaled respirable crystalline silica from occupational sources is carcinogenic to humans.

In making this evaluation, the IARC working group noted also that carcinogenicity was not detected in all industrial circumstances studied and may be dependent on inherent characteristics of the crystalline silica or on external factors affecting its biological activity.

A recommendation (SUM DOC 94 final) from the EU Scientific Committee for Occupational Exposure Limits (SCOEL) was adopted in June 2003. The main conclusions were as follows:

The main effect in humans of the inhalation of respirable silica dust is silicosis. There is sufficient information to conclude that the relative lung cancer risk is increased in persons with silicosis (and, apparently, not in employees without silicosis exposed to silica dust in quarries and in the ceramic industry). Therefore preventing the onset of silicosis will also reduce the cancer risk. Since a clear threshold for silicosis development cannot be identified, any reduction of exposure will reduce the risk of silicosis.

Other health effects

In scientific literature, papers are published about the possible association between silica exposure and scleroderma (an autoimmune disorder) and increased risk of kidney disease. Further information on this can be found in specialised literature on the relationship between silica exposure and health effects (Fubini 1998).

4. Risk Management – What do I need to do?

The aim of this section is to provide advice to the reader on when and how to apply the advice given in this Good Practice Guide to their specific circumstances.

Using a simple question and answer format, it will introduce basic risk management techniques that should be applied to workplace situations where persons may be exposed to respirable crystalline silica.

The advice given on the following pages will help the reader to decide to what extent this Good Practice Guide applies to their circumstances.

Guidance will be given on:

Assessment	How to **assess** whether there is a significant risk from exposure to respirable crystalline silica.

Control	How to decide what type of **control** and prevention measures should be put in place to treat the risks that are identified - ie to eliminate them, or to reduce them to an acceptable level.

Monitoring	How to **monitor** the effectiveness of the control measures in place. How to **monitor** workers' health.

Education	What information, instruction and training should be provided to the workforce in order to **educate** them about the risks to which they may be exposed.

The risk management processes of **Assessment, Control, Monitoring and Education** make up the foundation of all European health and safety legislation.

Question 1: How do I determine whether people are exposed to respirable crystalline silica in my workplace?

Answer: Respirable crystalline silica enters the body when dust containing a proportion of crystalline silica is inhaled. 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 respirable crystalline silica can occur in any workplace situation where airborne dust is generated, which contains a proportion of respirable crystalline silica. Occupational exposure to respirable crystalline silica occurs in many industries.

Use the simple flow chart below to carry out an initial assessment to determine whether there is any significant risk of exposure to respirable crystalline silica. The possible presence of fine particles of crystalline silica means that there may be a risk. If there is no foreseeable risk, then you don't need to take any specific measures. However, you should always obey the general principles of prevention.

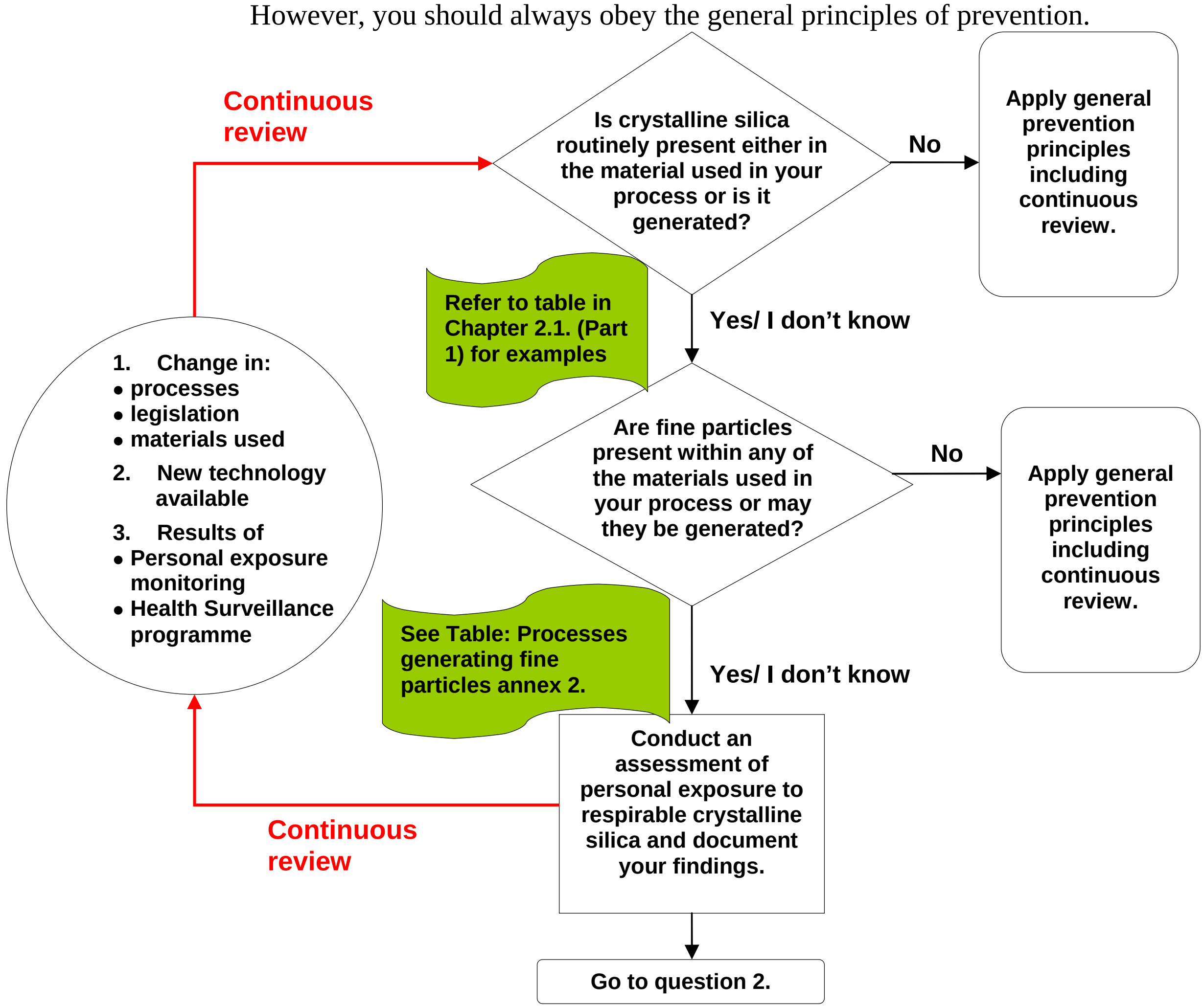


Figure: Initial assessment procedure.

The following table, taken from the Mining/Quarrying industry, is an example and may be helpful when assessing whether the processes in your specific workplace may cause the generation of fine particles which, if airborne, could lead to personal exposure to respirable crystalline silica.

Table: Processes generating fine particles which could result in respirable crystalline silica exposure:

MINE/QUARRY PROCESS	**Where may fine particles be generated?** (Non exhaustive list)
EXTRACTION (Mining and quarrying)	• Wind blown dust • Blasting • Ripping / bulldozing • Vehicle movements • Conveyor transport • Loading and unloading • Drilling
CRUSHING and MILLING	• All dry processes • Low risk in wet milling process
WASHING CHEMICAL TREATMENT SEPARATION	Low risk of airborne dust generation
DRYING AND CALCINING	All drying and calcining processes
DRY SCREENING DRY GRINDING	• All dry screening processes • All dry grinding processes
PACKAGING	• Bagging • Palletising • Vehicle Movements
STOCKPILING	• Wind blown dust from stockpiles • Vehicle Movements around stockpiles
LOADING and TRANSPORT	• Vehicle loading (free-fall of materials) • Vehicle movement • Conveyor transport
MAINTENANCE	Activities requiring dismantling/opening/access to equipment, or entry into dusty process areas listed above.
CLEANING	Cleaning activities involving entry into dusty process areas listed above and/or done using a dry brush or compressed air.

Other examples are given in annex 2.

Question 2: How do I conduct an assessment of personal exposure to respirable crystalline silica?

Answer: Use the simple flow chart below to help you to carry out your assessment of personal exposure levels. It's a good idea at this stage to make detailed notes of the dust control measures that are already in place in your workplace. You will need this information later, in order to assess whether you are complying with the general principles of prevention.

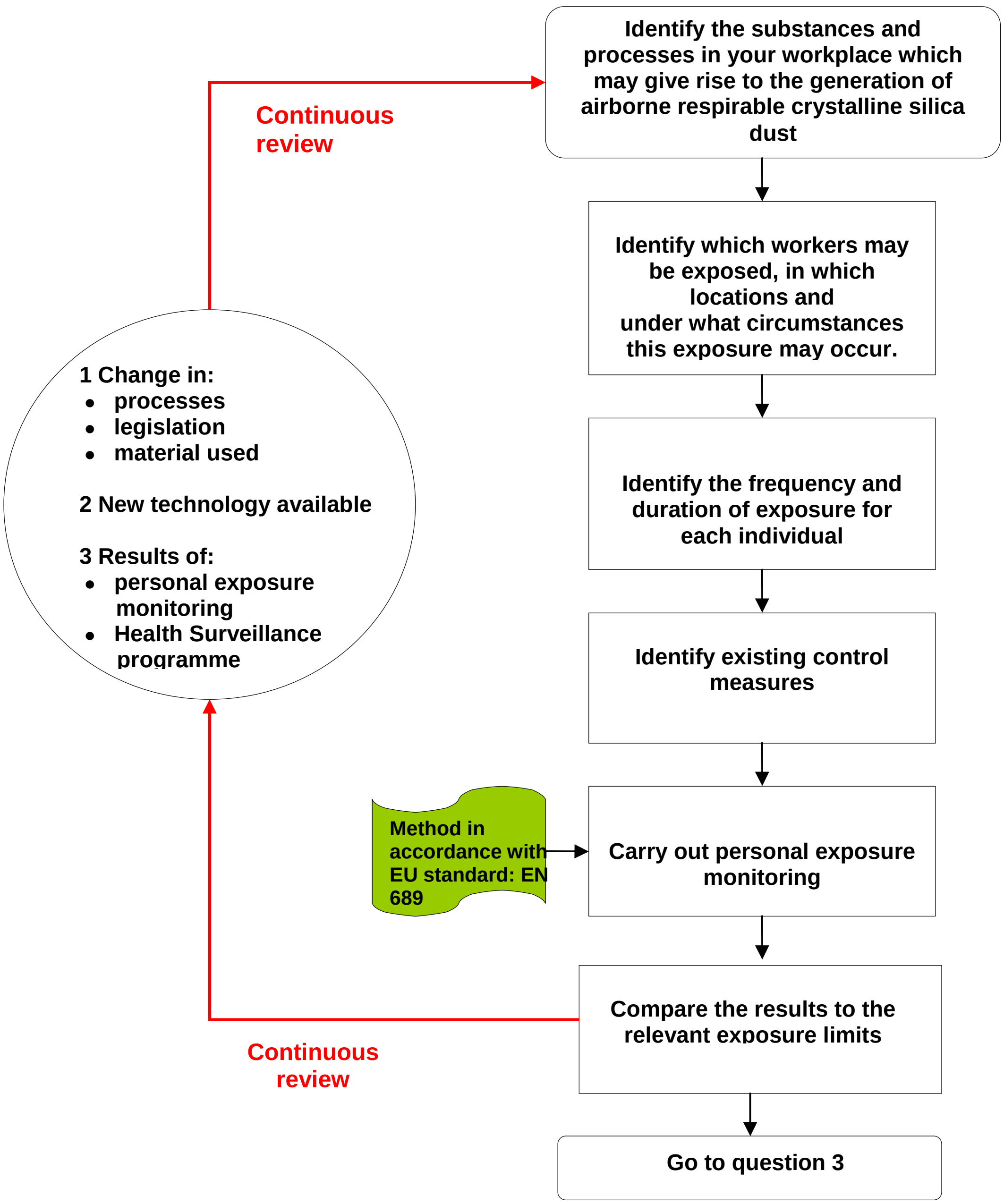


Figure: Assessment of personal exposure levels to respirable crystalline silica.

Personal Exposure Monitoring

The only way to quantify the amount of respirable crystalline silica present in the workplace atmosphere is to perform sampling of the air and analysis of the dust collected. Occupational exposure assessment is the process of measuring or estimating the intensity, frequency and duration of human contact with such contaminants.

There are two types of measurements commonly used:

- Personal;
- Static.

Both types of measurement can be used jointly as they are complementary.
It is up to the experts designated by the employers and the employees' representatives to opt for the most adequate solutions, while respecting the national and European provisions.

General requirements for dust monitoring (taken from the European Standards EN 689 and EN 1232) are provided in the "Dust Monitoring Protocol", **Annex 2** of the *Agreement on Workers Health Protection through the Good Handling and Use of Crystalline Silica and Products Containing it.* Producers and end users of products and raw materials containing crystalline silica are encouraged to adopt this protocol.

Advice on organising a dust-monitoring programme can be sought from a competent occupational hygienist.

Occupational Exposure Limits

An occupational exposure limit value represents the maximum time-weighted average concentration of an airborne contaminant to which a worker can be exposed, measured in relation to a specified reference period, normally eight hours.

Currently there are many different types of occupational exposure limit value, defined by individual Member States of the European Union (see annex). These limits are all different and, in addition, cannot be compared directly.

There is currently no European Union occupational exposure limit for respirable crystalline silica.

Question 3: **I have done my exposure assessment, but I'm not sure how to interpret the results. What do I need to do now?**

Answer: You need to compare the results of your assessment against the occupational exposure limit for respirable crystalline silica that applies in your country and you need to check that you are complying with the general principles of prevention.

It may be necessary for you to implement additional control measures (following the general principles of prevention) to eliminate, or reduce, exposure to respirable crystalline silica so that you meet the relevant occupational exposure limit.

In any case, you will need to provide training to your workforce on the risks to their health, which may arise from exposure to respirable crystalline silica and how to use the control measures provided.

The following flow chart will guide you through the process.

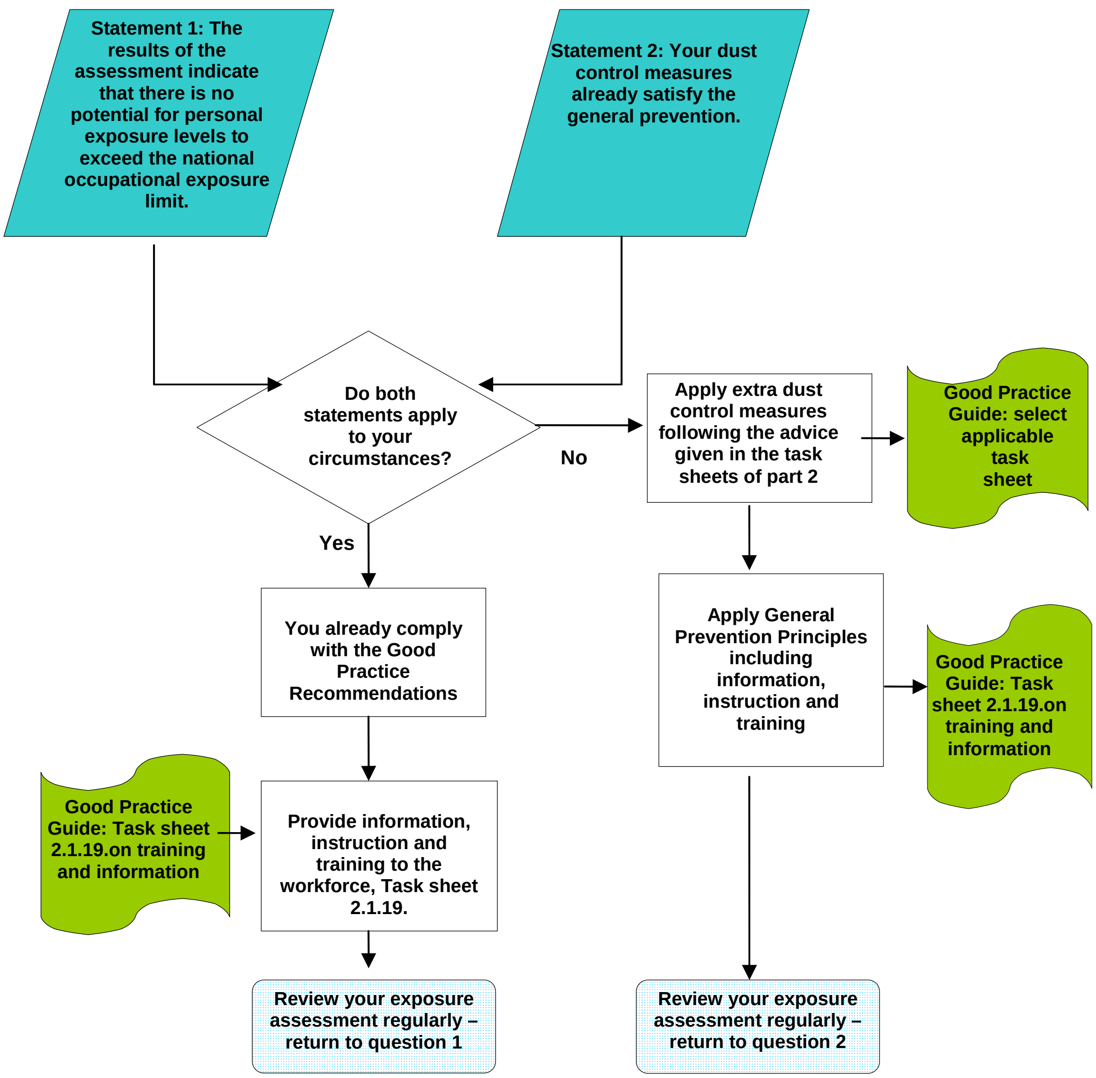


Figure: Simple decision flow chart for control of exposure to respirable crystalline silica.

General prevention principles

In the development of this Good Practices guide, the authors respected the prevention strategy, which is described in Council Directive 89/391/EEC and in its transposition in the national laws.

Nine prevention principles are described and one must consider the following hierarchy in the preventive measures to be taken:

- avoiding risks
- evaluating the risks which cannot be avoided
- combating the risks at source
- adapting the work to the individual
- adapting to technical progress
- replacing the dangerous by the non dangerous or the less dangerous
- developing a coherent overall prevention policy (including the provision of health surveillance of workers)
- giving collective protective measures priority over individual protective measures
- giving appropriate information, instruction and training to the workers

In the context where crystalline silica is handled in the workplace, examples of practical applications of the above principles are:

- **Substitution:** taking into account economic, technical and scientific criteria, replace a dust-generating process with a process generating less dust (e.g. use of a wet process instead of a dry process, or an automated process instead of a manual process).
- **Provision of engineering controls:** de-dusting systems (dust suppression[1], collection[2] and containment[3]) and isolation techniques[4].
- **Good housekeeping practices.**
- **Work pattern:** establish safe working procedures, job rotation.
- **Personal protective equipment:** provide protective clothing and respiratory protective equipment.
- **Education:** provide adequate health and safety training to the workers, information and instructions specific to their workstation or job.

Compliance with Member State Occupational Exposure Limits is just one part of the Risk Management process. You should additionally always ensure that you comply with the General Principles of Prevention, as defined in Council Directive 89/391/EEC.

[1] e.g. water, steam, mist or fog sprays.
[2] e.g. cyclones, scrubbers, bag filters, electrostatic precipitators and vacuum cleaners.
[3] e.g. encapsulation
[4] e.g. control room with a clean air supply

Training for the Workers

One of the task sheets in Part 2 of this guide gives detailed guidance on the format and content of training, which should be provided to workers to inform them of the risks to their health that may arise from the handling and use of substances containing crystalline silica.

Risk Management - Summary

The following diagram summarises the risk management process, from the perspective of both employer and employee, when applied to control of respirable crystalline silica.

The health and safety systems implemented in the companies must be respected by both employer and employee.

EMPLOYERS **Management Health and Safety Policy**		**EMPLOYEES** **Participation/Co-operation with employer**
Risk assessment with involvement of employees		Contribution to the risk assessment process
Measurement of exposure levels		Follow safe working procedures
Investment in engineering controls		Attend health surveillance
Develop safe working procedures	**CONTROL OF RISKS**	Attend training
Information, instruction and training for the workforce		Wear personal protective equipment
Provision of personal protective equipment		Communicate problems to employer
Provision of health surveillance		
Ensure a good involvement of employees' representatives		
Take into account all types of employees, i.e. contractors, temporary, fixed term contract, agency, students on work experience, young people and new employees.		

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Glossary

Aerodynamic diameter: diameter of a sphere of density $1g.cm^{-3}$ with the same terminal falling velocity in the air, related to the particle in question, in the same conditions of temperature, pressure and relative humidity.

Bagging: a process during which products are put into bags (manually or automatically).

Control measures: measures carried out in order to reduce personal exposures of a workplace contaminant to an acceptable level.

Crushing: a process during which coarse material is broken down (crushed) into smaller fragments.

Dust: a dispersed distribution of solids in air, brought about by mechanical processes or stirred up.

Epidemiology: the study of the distribution and causes of health-related conditions and events in populations and the application of this study to control health problems.

Exposure: inhaled exposure results from the presence of an airborne contaminant in the air within the breathing zone of a worker. It is described in terms of the concentration of the contaminant, as derived from exposure measurements and referred to the same reference period as that used for the occupational exposure limit value.

Exposure assessment: the process of measuring or estimating the intensity, frequency and duration of human contact with airborne contaminants which may be present in the working environment.

Grinding: the minerals production process in which individual mineral grains are broken down to a required particle size, typically to a fine flour. The process is sometimes also referred to as “milling” since it is carried out inside a grinding mill.

Hazard: an intrinsic property of a substance with the potential to cause harm.

Health surveillance: the assessment of an individual worker to determine the state of health of that individual.

HSE: The United Kingdom Health and Safety Executive.

IARC: International Agency for Research on Cancer.

Inhalable dust (also referred to as Total inhalable dust): the fraction of an airborne material which enters the nose and mouth during breathing and which is therefore available for deposition anywhere in the respiratory tract (MDHS 14/2). The standard EN 481 gives the percentage of the suspended total particulate that can be inhaled according to particle size.

INRS: Institut National de Recherche et de Sécurité.

ISO: International Standardisation Organisation.

Measurement: a process carried out in order to determine the airborne concentration of a substance in the workplace environment.

Measurement procedure: a procedure for sampling and analysing one or more contaminants in workplace air.

Milling: the minerals production process in which the lumps of mineral are broken down to individual grains. See also "grinding".

Occupational exposure limit value: the maximum admissible exposure of a worker to an airborne contaminant that is present in the air in the workplace. It represents the maximum time-weighted average concentration of an airborne contaminant to which a worker can be exposed, measured in relation to a specified reference period, normally eight hours.

Personal protective equipment: equipment designed to be worn or otherwise held by the worker to protect him against one or more hazards likely to endanger his safety and health at work, or any addition or accessory designed to meet this objective.

Personal sampler (or personal sampling device): a device worn by a person that samples the air in that person's breathing zone, in order to determine his personal exposure to airborne contaminants.

Pulmonary alveolar region: the gas exchange region of the lung, made up of approximately 300 million alveoli, or air sacs.

Prevention: the process of eliminating or reducing occupational health and safety risks.

Respirable dust fraction: fraction of an airborne material that penetrates to the gas exchange region of the lung.

Risk: likelihood that the potential for harm will be realised under the conditions of use and/or exposure.

Standard: Document elaborated by consensus and agreed by an approved organisation with standardisation activities. This document gives, for common and repeated practices, rules and guidelines on how an activity should be conducted.

Static sampler: sampling device positioned at a fixed point in the workplace for the duration of a measurement (as opposed to being worn by a person).

Thoracic dust fraction: fraction of an airborne material that penetrates beyond the larynx.

Workplace: the whole area intended to house workstations and accommodation, where provided, to which workers have access in the context of their work.

Annex 1: Table of Occupational Exposure Limit values (in mg/m³) – January 2006 *(to be extended to EU 25)*

The following table shows the Occupational Exposure Limits (OEL) for quartz, cristobalite and tridymite in application in European countries. As soon as new occupational exposure limits (in mg/m³) appear in a country, they will implicitly be integrated in this document.

	OEL Name	Adopted by	Quartz	Cristobalite (c)	Tridymite
Austria	Maximale ArbeitsplatzKoncentration	Bundesministerium für Arbeit und Soziales	0.15	0.15	0.15
Belgium		Ministère de l'Emploi et du Travail	0.1	0.05	0.05
Denmark	Threshold Limit Value	Direktoratet fot Arbeidstilsynet	0.1	0.05	0.05
Finland	Occupational Exposure Standard	National Board of Labour Protection	0.2	0.1	0.1
France	Empoussiérage de référence	Ministère de l'Industrie (RGIE)	5 or 25k/Q		
	Valeur limite de Moyenne d'Exposition	Ministère du Travail	0.1	0.05	0.05
Germany	Grenzwert nach TRGS 900	Bundesministerium für Arbeit	-[5]	-	-
Greece		Legislation for mining activities	0.1[6]	0.05	0.05
Ireland		2002 Code of Practice for the Safety, Health & Welfare at Work (CoP)	0.05	0.05	0.05
Italy	Threshold Limit Value	Associazone Italiana Degli Igienisti Industriali	0.05	0.05	0.05
Luxembourg	Grenzwert nach TRGS 900	Bundesministerium für Arbeit	0.15	0.15	0.15
Netherlands	Maximaal Aanvarde Concentratie	Ministerie van Sociale Zaken en Werkgelegenheid	0.075	0.075	0.075
Norway	Administrative Normer (8hTWA) for Forurensing I ArbeidsmiljØet	Direktoratet for Arbeidstilsynet	0.1	0.05	0.05
Portugal	Threshold Limit Value	Instituto Portuges da Qualidade, Hygiene & Safety at Workplace	0.1	0.05	0.05
Spain	Valores Limites	1) Instituto Nacional de Seguridad e Higiene	0.1	0.05	0.05
		2) Reglamento General de Normas Basicas de Seguridad Minera	5 or 25k/Q		
		2.1) New proposal (except coal mining)	0.1	0.05	0.05
Sweden	Yrkeshygieniska Gränsvärden	National Board of Occupational Safety and Health	0.1	0.05	0.05
Switzerland	Valeur limite de Moyenne d'Exposition		0.15	0.15	0.15
United Kingdom	Workplace Exposure Limit	Health & Safety Executive	0.3[7]	0,3	0,3

Q : quartz percentage
K: noxious coefficient (equal to 1)
Source : Adapted from IMA-Europe, Date : 07/01/04, updated version available at http://www.ima-eu.org/en/silhsefacts.html
OELs are applicable to 100 % quartz, cristobalite or tridymite. Some countries have special rules for mixed dust, e.g. in France the following equation is applied: $C_{ns}/5 + C_q/0.1 + C_c/0.05 + C_t/0.05 \leq 1$ (C = mean concentration, ns = non silica content, q = quartz content, c = cristobalite content, t = tridymite content) where all variables are in mg/m³.

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5 In Germany there are no OELs for crystalline silica since 2005; instead of an OEL there is a workers health protection system.

6 According to Mining Legislation Code and the Presintential Degree 307/1986, the occupational exposure limit value to respirable crystalline silica is calculated according to the following formula: OEL = 10/ (%Q+2) where Q= % concentration of free crystalline silica in the respirable fraction of the dust

7 In the United Kingdom an Exposure Limit 0.1 mg/m³ is expected.

Annex 2

Tables of processes generating fine particles which could result in respirable crystalline silica exposure

1. Processes generating fine particles which could result in respirable crystalline silica exposure in the cement production:

The level of RCS may depend on the type of materials used.
The risk of presence of respirable crystalline silica (RSC) is low and is limited to the first phases of the cement production process (extraction/quarrying; transport of raw materials, grinding/crushing, raw mill). In and after the kiln system, the risk is negligible.

Cement Production	Where may RCS be formed?
Extraction/quarrying	Wind blown dust Blasting Ripping bulldozing
Transport of raw materials	Vehicle movements (mostly closed systems) Conveyor transport (mostly closed systems) Loading and unloading (mostly closed systems)
Grinding/crushing	Raw material processing: clay, sand, limestone, diatomaceous earth
Raw meal	Blown dust (mostly closed systems) Maintenance (mostly closed systems)
Blending, storage and transport raw meal	-
Kiln	-
Transport and storage	-
Cement mill	-
Packaging	Bagging Palletising
Transport	Vehicle loading Vehicle movement
Maintenance	Activities requiring dismantling/opening/access to equipment, or entry into dusty process areas listed above, including filters Risk is strongly linked to the type of materials (i.e. step in production process)
Cleaning	Cleaning activities involving entry into dusty process areas listed above

2. Processes generating fine particles which could result in respirable crystalline silica exposure <u>in the glass and mineral wool industries</u>:

Glass Manufacturing	Where can fine crystalline silica particles be produced ?
Raw Material Storage	When no silo storage - wind dispersion - loading / unloading - transporting (conveyor belt)
Batch Preparation	- mixing - conveying - cleaning
Loading and Transport	- batch ingredients
Batch Charge	- manual charge of batch - automated charge of batch
Filter Installation	- operating - cleaning - maintenance - repair
Cleaning Operations	- batch conveyor installation - furnace parts
Repair and Dismantling Operations	- batch conveyor installation - furnace parts

3. Processes generating fine particles which could result in respirable crystalline silica exposure <u>in the ceramics industry</u>:

CERAMICS (*) PROCESS	**Where may fine particles be generated?** (Non exhaustive list)
Supply, Unloading, Transport, Storage	• Vehicle movement • Vehicle unloading / Bulk unloading • Bulk road tanker unloading (blowing off) • Bag emptying • Conveyor transport • Other transport systems
Raw material's preparation for body and Glaze	• Proportioning • Mixing of materials • Grinding / Milling • Screening • Dewatering (Spray drying) Low risk in wet processes: • Wet milling • Plastification • Resolving
Shaping	• Dry pressing • Isostatic pressing • Green shaping by machining • Dressing of casted parts • Garnishing Low risk in wet processes: • Mould making • Slip casting • Plastic shaping
Drying	• Periodic and continuous drying
Glazing	• Spray glazing Low risk in wet processes: • Glazing by dipping • Glazing by watering • Decoration
Firing	• Firing (Biscuit-, final-, decoration-, …)
Subsequent treatment	• Grinding • Polishing • Cutting / sawing • Drilling Low risk of airborne dust generation: • Sorting • Packaging

CERAMICS (*) PROCESS	Where may fine particles be generated? (Non exhaustive list)
Maintenance	• Cutting Refractory Materials (for kilns) • Removing dust or sludge from an extraction unit
Cleaning	• Dry cleaning Low risk of airborne dust generation: • wet cleaning

(*) not every process step is necessary for every ceramic product

4. Processes generating fine particles which could result in respirable crystalline silica exposure in the foundry industry:

Casting Production	Where may fine particles be generated ?
Sand transport and storage	Pneumatic conveying
Sand preparation	Mixing Transport
Core making and Moulding	Mixing Transport
Melting shop	Lining and break-out of refractory material (ladles, furnaces)
Knockout	Separating castings from sand
Fettling shop	Shot-blasting Grinding of castings

5. Processes generating fine particles which could result in respirable crystalline silica exposure in the <u>precast concrete industry:</u>

Precast Concrete manufacturing	**Where can fine crystalline silica particles be produced ?**
RAW MATERIALS (Supply, unloading, transport and storage)	General storage (indoor and outdoor) Handling and transportation systems Bag emptying Bulk loading/unloading Crushing/grinding of minerals
CONCRETE MANUFACTURE Generally wet process	Mixing of materials Proportioning of bulk materials Drying Water assisted dust suppression Plastic shaping
POST-PRODUCTION	Final treatment (dry) General storage (indoor and outdoor) Handling and transportation systems
Cleaning	Mould cleaning Handling and transportation systems
Not every process step is necessary for every precast concrete product	

Part 2: Task manual

The aim of this part of the Good Practices Guide on dust prevention is to reduce risks to which workers may be exposed from respirable crystalline silica.

The first section is an introduction on respirable crystalline silica.

The second section contains a range of task guidance sheets which describe good practice techniques for various common and specific tasks. The general guidance sheets (section 2.1.) apply to all of the industries which are signatories of the Agreement on Workers' Health Protection through the Good Handling and Use of Crystalline Silica and Products containing it. The specific task sheets (section 2.2.) relate to tasks concerning only a limited number of industry sectors.

1. Introduction

What is respirable crystalline silica?

By definition, respirable crystalline silica is the fraction of airborne crystalline silica dust that can penetrate the alveoli (gas exchange region) of the lung.

In the case of crystalline silica dust, it is the respirable fraction of the dust that is of concern for its health effects. These particles are so small that they cannot be seen with the naked eye. Once airborne, respirable dust takes a very long time to settle. A single release of dust into the workplace air can lead to significant exposure. In fact, in situations where the air is constantly stirred up and where no fresh air is being introduced, respirable dust may remain airborne in the workplace for days.

How does respirable crystalline silica get into the body?

Respirable crystalline silica enters the body when dust containing a proportion of crystalline silica is inhaled. 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.

What are the known health effects associated to respirable crystalline silica exposure?

The principal health effect associated to the inhalation of respirable crystalline silica is silicosis.

Silicosis is one of the most common types of pneumoconiosis. Silicosis is a nodular progressive fibrosis caused by the deposition in the lungs of fine respirable particles of crystalline silica. When one experiences prolonged overexposure, the body’s natural defence mechanisms may find it difficult to clear respirable crystalline silica from the lungs. An accumulation of dust can, in the long term, lead to irreversible health effects. These health effects involve scarring of the innermost parts of the lungs that can lead to breathing difficulties and, in some cases, death. Larger (non-respirable) particles are more likely to settle in the main airways of the respiratory system and may be cleared by mucus action.

Silicosis is one of the world's oldest known occupational diseases and is caused by the inhalation of respirable crystalline silica (Stacey P.R 2005).

Workers are rarely exposed to pure crystalline silica. The dust they breathe in the workplace is usually composed of a mixture of crystalline silica and other materials.

The response of an individual is likely to depend on:

- the nature and silica content of the dust
- the dust fraction
- the extent and nature of personal exposure (duration, frequency and intensity, which may be influenced by the working methods)
- personal physiological characteristics
- smoking habits

Where is respirable crystalline silica found?

Occupational exposure to respirable crystalline silica can occur in any workplace situation where airborne dust is generated, which contains a proportion of respirable crystalline silica.

Occupational exposure to respirable crystalline silica occurs in many industries including quarrying, mining, mineral processing (e.g. drying, grinding, bagging and handling); slate working; stone crushing and dressing; foundry work; brick and tile making; some refractory processes; construction work, including work with stone, concrete, brick and some insulation boards; tunnelling, building restoration (painting) and in the pottery and ceramic industries.

How to use the Task Sheets

At each site, before commencing any work activity that may result in occupational exposure to respirable crystalline silica, employers must carry out a risk assessment to identify the source, nature and extent of that exposure.

When the risk assessment identifies that workers may be exposed to respirable crystalline silica, then control measures should be put in place to control exposures.

The following task sheets identify appropriate control measures that will assist employers in reducing exposure levels for many common work activities. When deciding which task sheet(s) to apply, priority should be given to the most significant sources of exposure to respirable crystalline silica in the workplace.

Depending on the specific circumstances of each case, it may not be necessary to apply all of the control measures identified in the task sheets in order to minimise exposure to respirable crystalline silica i.e. to apply appropriate protection and prevention measures as required by Section II of Directive 98/24.

2. Task Guidance Sheets

	Aggregates	Cement	Ceramic	Precast Concrete	Foundry	Glass	Industrial Minerals	Mineral Wool	Mining	Mortar	Natural Stones
2.1. General Guidance Sheets											
2.1.1. Cleaning	X	x	x	x	x	x	x	x	x	x	x
2.1.2. Design of buildings	X	x	x	x	x	x	x	x	x	x	x
2.1.3. Design of control rooms	X	x	x	x	x	x	x	x	x	x	x
2.1.4. Design of ducting	X	x	x	x	x	x	x	x	x	x	x
2.1.5. Design of dust extraction units	X	x	x	x	x	x	x	x	x	x	x
2.1.6. Dust monitoring	X	x	x	x	x	x	x	x	x	x	x
2.1.7. General indoor storage	X	x	x	x	x	x	x	x	x	x	x
2.1.8. General outdoor storage	x	x	x	x	x	x	x	x	x	x	x
2.1.9. General ventilation	X	x	x	x	x	x	x	x	x	x	x
2.1.10. Good hygiene	X	x	x	x	x	x	x	x	x	x	x
2.1.11. Handling and transport systems	x	x	x	x	x	x	x	x	x	x	x
2.1.12. Laboratory work	X	x	x	x	x	x	x	x	x	x	x
2.1.13. Local exhaust ventilation	X	x	x	x	x	x	x	x	x	x	x
2.1.14. Maintenance, service & repair activities	x	x	x	x	x	x	x	x	x	x	x
2.1.15. Personal protective equipment	X	x	x	x	x	x	x	x	x	x	x
2.1.16. Removing dust or sludge from an extraction unit	X	x	x	x	x	x	x	x	x	x	x
2.1.17. Supervision	x	x	x	x	x	x	x	x	x	x	x
2.1.18. Systems of packaging	X	x	x	x	x	x	x	x	x	x	x
2.1.19. Training	X	x	x	x	x	x	x	x	x	x	x
2.1.20. Working with contractors	x	x	x	x	x	x	x	x	x	x	x
2.2. Specific task sheets											
2.2.1. (a) Bag emptying – small bags	x	x		x	x	x	x		x	x	
(b) Bag emptying – bulk bags	x	x		x	x	x	x		x	x	
2.2.2. Batch charging into the process - Glass						x					
2.2.3. (a) Bulk road tanker loading	x			x	x		x		x	x	
(b) Bulk loading	x	x		x			x		x	x	
2.2.4. (a) Bulk road tanker unloading (blowing off)	x		x	x	x	x	x		x	x	
(b) Bulk unloading	x	x		x	x	x	x		x	x	
2.2.5. Core making and moulding in foundries					x						

2. Task Guidance Sheets

		Aggregates	Cement	Ceramic	Precast Concrete	Foundry	Glass	Industrial Minerals	Mineral Wool	Mining	Mortar	Natural Stones
2.2.6.	Crushing of minerals	x	x		x			x		x		
2.2.7.	Cutting and polishing refractory materials and glass			x		x	x					
2.2.8.	Drying minerals	x	x					x			x	
2.2.9.	Dry pressing			x								
2.2.10.	Fettling larger castings in foundries					x						
2.2.11.	Fettling smaller castings in foundries					x						
2.2.12.	Final treatment (dry)			x	x							
2.2.13.	Firing (biscuit, glaze, final, decoration)			x								
2.2.14.	Glass furnace batch charging - container glass						x					
2.2.15.	Glass sandblasting						x					
2.2.16.	Grinding of minerals	x	x		x			x				
2.2.17.	Grinding of glass						x					
2.2.18.	Isostatic pressing (dry)			x								
2.2.19.	Jumbo bagging	x	x			x		x			x	
2.2.20.	Knock-out and shake-out in foundries					x						
2.2.21.	Lining and Break-out					x						
2.2.22.	Mixing of materials		x	x	x	x	x	x			x	
2.2.23.	Periodic and continuous drying			x	x	x						
2.2.24.	Plastic shaping			x	x							
2.2.25.	Preparation			x								
2.2.26.	Preparing sand in foundries					x						
2.2.27.	(a) Proportioning (small quantities)			x								
	(b) Proportioning of bulk materials			x	x							
2.2.28.	Quarry mobile plant – excavation and haulage	x	x					x		x	x	
2.2.29.	Screening	x	x					x		x		
2.2.30.	Shot-blasting in foundries					x						
2.2.31.	(a)Small bag filling – coarse products							x			x	
	(b) Small bag filling - flours		x					x			x	
2.2.32.	Spray drying			x	x							
2.2.33.	Spray glazing			x								
2.2.34.	Transport systems for fine dry silica products			x				x				
2.2.35.	Use of a drilling rig	x	x					x		x		
2.2.36.	Water assisted dust suppression		x	x	x							