Handbook for Implementation of

"Agreement on Workers' Health Protection through the Good Handling and Use of Crystalline Silica and Products Containing it"

GUIDELINES FOR MONITORING EXPOSURE

(Updated: 30.03.09)

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This handbook has been financed by the Working Environment Fund of the NHO (Confederation of Norwegian Enterprise), contributions from companies involved, federations and associations, and in-house efforts.

Contents

Guidelines for monitoring exposure

Through the Silica Agreement, “Good Practice” has been drawn up for measuring exposure/dust, which stipulates that this should be carried out in accordance with the European Standards NS-EN 689 (ref. 2) and NS-EN 1232 (ref. 3). These standards also form the basis for the Norwegian Labour Inspection Authority’s guide AT 450, “Mapping chemical and biological contamination in the working atmosphere” (ref. 4). This handbook has used AT 450 as its basis for compiling a practical guide for exposure measurements of crystalline silica dust in accordance with the Silica Agreement.

The guidelines have been compiled with a view to enabling the employer/persons responsible for operations with quartz exposure to use them as an order description for quartz measurements from its company health service, and to enable the company health service to use them as a guide for the practical implementation of this mapping.

Section 2 describes general guidelines, and sections 3 and 4 provide practical information on dust measurements and report writing.

1. Current regulations

The Silica Agreement is a supplement to the current regulations. The occupational exposure limit (OEL) provided for quartz dust in the working atmosphere therefore still applies. While the Silica Agreement only applies to respirable silica dust, the occupational exposure limits are also applicable in Norway for crystalline silica total dust. Measuring the total dust crystalline silica fraction is an expensive and complicated procedure for the laboratory, and does not provide any major additional knowledge in the assessment of health risks when the respirable fraction is known.

The applicable occupational exposure limits in Norway for quartz are (ref. 5):

- 0.1 mg/m^3 for respirable dust
- 0.3 mg/m^3 for total dust
- Labelled C (carcinogenic)

The occupational exposure limit stipulates the highest acceptable average concentration for an 8-hour working day, and is determined based on technical, financial and medical considerations.

2. Exposure mapping

The exposure mapping should be carried out using a step-by-step process. How extensive this will be, depends on what is already known and what is revealed about the exposure.

The mapping and evaluation process consists of the following main stages (see figure 1):

1) Preliminary evaluation - qualitative
2) Preliminary study – quantitative sampling tests
3) Detailed study – representative quantitative measurements
4) Periodic measurements – systematic representative quantitative measurements

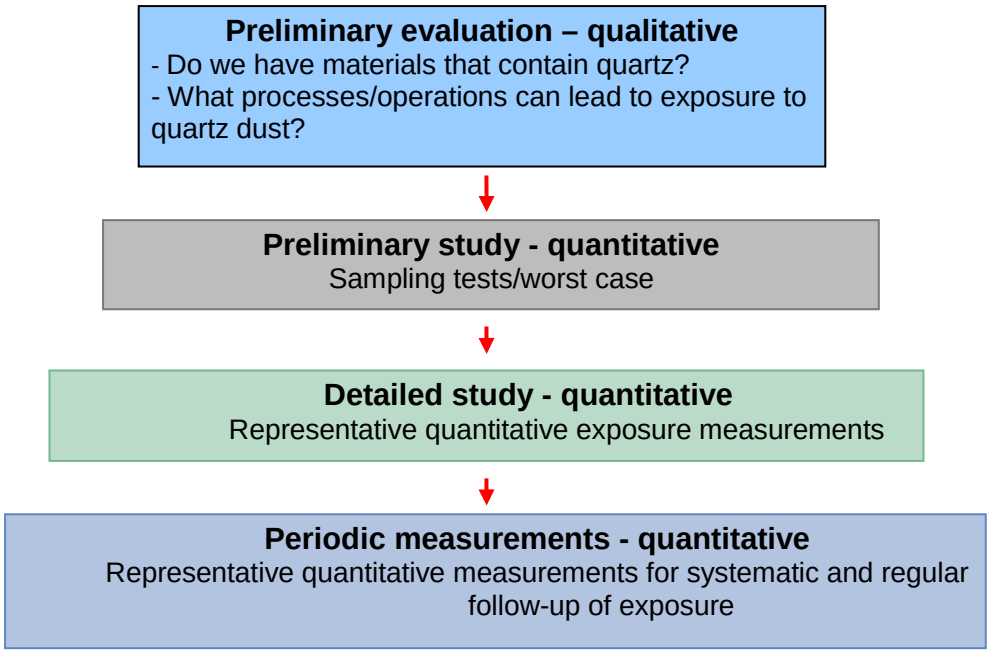

Figure 1. Main stages of the mapping process (ref. 1)

The actual mapping should be carried out in accordance with AT 450 (ref. 4). The most important features are described in the following paragraphs. For a complete description of the mapping, it is recommended that AT 450 is studied.

Consideration will be given after each stage to whether the knowledge base is sufficient to make a decision, i.e. whether the exposure level is acceptable or if measures need to be implemented, or if more information is needed on the level of exposure.

Where the mapping indicates that the exposure level is close to the occupational exposure limit (1/4 OEL – 1/1 OEL), the exposure must be followed up regularly with periodic measurements. This is based on recommendations given in AT 450 (ref. 4).

It is crucial that advice is sought throughout the exposure mapping process from persons with process knowledge and experience from the company or similar companies.

Stage 1: Preliminary evaluation

The preliminary evaluation shall indicate whether it is possible for personnel to be exposed to respirable crystalline silica (RCS). This evaluation is based on qualitative information.

The following conditions, which can lead to exposure, should be evaluated:

- Use of quartzeous materials (check HSE datasheets)
- Formation and release of quartz dust into the working atmosphere from production processes

If quartz exposure potential is indicated, an impression of the volume of quartz dust that personnel may be subjected to can be ascertained by evaluating the following:

- Do any personnel in the workplace have ailments or illnesses that can be due to exposure, or has anyone that has left the company had such conditions?
- The distance between contamination sources and personnel
- The time spent in contaminated zones

- Working habits of personnel
- Seasonal variations
- Operations such as cleaning and maintenance
- Ventilation
- Use of respiratory protective equipment
- Previous measurements and any changes in the work process since these measurements were taken.

Conclusion after the preliminary evaluation:

Conclusion	Consequence
No exposure exists and no changes are expected.	The mapping is concluded with a report.
More information is needed on the exposure level.	Continue with the preliminary study.
Major exposure levels exist.	Initiate exposure-reducing measures and new mapping
Major exposure levels and suspicion that the exposure has led to or can lead to damage to health.	Detailed study must be undertaken in addition to exposure-reducing measures.

More information is needed if the exposure level is unclear, or if exposure exists but is not regarded as major.

Stage 2: Preliminary study

The aim of the preliminary study is to obtain more information on the degree of exposure that personnel are subjected to, and particularly on tasks with a potentially high level of exposure.

The following information can be used in the evaluation:

- Information from the preliminary evaluation
- Measurements from similar companies or operations
- Calculations based on quantitative data (for example the amount of crystalline silica that is used in relation to air change)
- Sampling tests and measurements near the sources.

Sampling tests

Sampling tests are individual samples, often taken over a relatively short sampling period. However, it should be noted that sampling periods that are too short can mean that the amount of dust is insufficient for the laboratory to measure the quartz. Any concerns about the required sampling period can be discussed with the laboratory.

The number of tests can vary. However, a minimum of three measurements are recommended per measuring location.

Sampling tests can be carried out as follows:

- Estimated maximum exposure (worst case) in order to establish whether there are operations that are distinguished by a particularly high level of exposure, or:
- Under representative conditions of personnel carrying out their normal operations, or:
- Near the emission source.

Evaluation of the sampling test depends on how it is carried out:

Worst case testing:

- Values greater than 1.5 x OEL mean that the exposure is above the OEL.
- Values less than 1/4 of the OEL mean that the exposure is below the OEL by a wide margin, and that this also applies to other personnel in the group.

Representative testing:

- Values greater than the OEL mean that the exposure is above the OEL.
- Values less than 1/10 of the OEL mean that the exposure is below the OEL by a wide margin for the group of personnel studied.

Measurements near the emission source:

- Must be evaluated based on the probability of personnel spending time in this zone.

Conclusion after the preliminary study:

Conclusion	**Consequence**
The exposure is below the OEL by a wide margin, and no change is expected.	The mapping is concluded with a report.
More information is needed on the level of exposure.	Continue with a detailed study. Resources can be used to implement measures.
Exposure is above the OEL.	Initiate exposure-reducing measures and new mapping

Stage 3: Detailed study

The aim of the detailed study is to obtain representative quantitative data on the employees' exposure via individual measurements. In order to ensure that the data are representative, the selection of personnel/operations and testing period are extremely important.

A strategy has been drawn up based on the grouping of personnel with an assumed equal level of exposure, known as homogeneous groups. Measurements taken of personnel in a homogeneous group are regarded as applicable to all group members. Measuring a selection of group members is therefore sufficient.

If it is not possible to divide personnel into homogeneous groups, personnel must be randomly selected from the entire group that is exposed. However, this requires a greater number of tests.

Number of persons and tests

It is recommended that the measurements are carried out on as many personnel as possible and a minimum of two measurements are taken per person. The number of persons and number of tests that form part of a sampling strategy in relation to AT 450 (ref. 4) are as follows:

No. of persons in homogeneous group	1	2	3	4	5	6	7-9	10-14	15-26	27-50	>50
No. of persons tested	1	2	3	4	5	5	6	7	8	9	10
Total no. of tests	5	8	9	10	10	10	12	14	16	18	20

Persons tested should be randomly selected.

Sampling period
Based on the occupational exposure limit, tests should be taken throughout the course of a working day as these limits are set for an 8-hour working day. Tests taken from the breathing zone throughout the entire working cycle give measuring results that are normally regarded as representative of the employees' local exposure levels.

It is recommended that measurements are taken with intervals of, for example, a few weeks. By doing so, it is possible to intercept variations that can be caused by a change in duties, raw materials, processes, and weather and seasonal variations.

Evaluating the homogeneity
The exposure patterns within a homogeneous group can still be subject to random and systematic differences. It is therefore necessary to test whether the group is homogeneous.

If the average exposure (arithmetic average value) for at least one of the group members is less than half or more than double the average for the group as a whole, the relevant working environment factors should be re-evaluated with a view to a further division of the group.

Conclusion after the detailed study:

Conclusion	Consequence
The exposure (average of the measuring results) is less than 1/4 of the OEL and no change is expected.	The mapping is concluded with a report.
The exposure (average of the measuring results) is above 1/4 of the OEL, but not above the OEL.	Periodic measurements are required and measures must be considered. The reason for individual values exceeding the OEL should be clarified.
The exposure (average of the measuring results) is above the OEL.	Initiate exposure-reducing measures and new mapping

Stage 4: Periodic measurements

Periodic measurements (ref. 4) are carried out when the exposure is so high that the risk of exceeding the OEL is present if minor changes in the exposure pattern occur. This is the case when exposure measurement results from the detailed study are between ¼ of the OEL and 1/1 of the OEL. The aim is to monitor the exposure over time. Representative measuring points are selected based on the previous mapping.

The number and frequency of tests depends on the results from the detailed study or the previous periodic study. In order to uncover any changes it is important that agreed testing

patterns are retained over time, that the same persons are monitored and that the measurements are carried out under equivalent conditions.

Conclusion after the periodic measurements:

Conclusion	Consequence
The exposure (average value of all measurements) is less than ¼ of the OEL.	The mapping is concluded with a report.
The exposure (average value of all measurements) is more than 1/4 of the OEL, but does not exceed the OEL.	Re-evaluate the conditions within 64 weeks.
The exposure (average value of all measurements) is above the OEL.	Initiate exposure-reducing measures and new mapping

When the mapping is completed

In all cases, a new exposure evaluation must be undertaken in the event of changes to processes/materials/raw materials that can affect the exposure to silica dust. When the mapping is concluded with a report, a new exposure evaluation should be initiated after, for example, two years. This period of time is determined based on the conditions at the workplace, but it is recommended that the period is not longer than three years.

3. Dust measurements

3.1 Principle

Dust measurements in the working atmosphere are taken by pumping the air through a filter at a set and calibrated flow rate. The dust that is deposited in the filter can then be analysed by a laboratory. In order to be able to measure the volume of the various fractions of the dust (see figure 2), the pump must be equipped with a cyclone for separating the dust fractions by particle size (aerodynamic diameter). The respirable fraction is dominated by particles with an aerodynamic diameter of less than 5 µm.

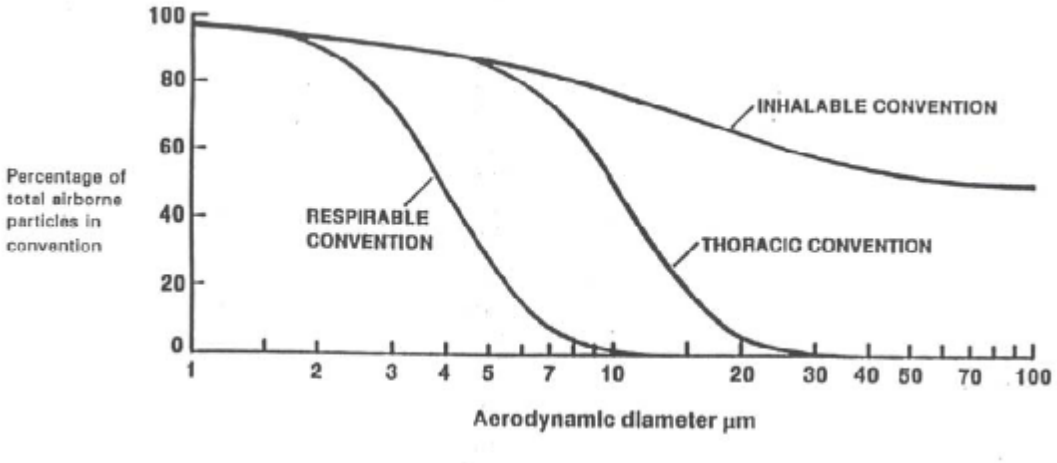

Figure 2. Dust fractions as a function of aerodynamic diameter (ref. 1)

Figure 3 shows sampling equipment with a cyclone for respirable dust fraction. The pump in the picture has a rotameter for adjusting the flow in the pump, but a separate rotameter or an electronic flow meter can also be used for this purpose.

Figure 3. Sampling equipment. A dismantled cyclone is shown at the left of the picture, with a test cassette and filter in the centre. At the right is shown an assembled cyclone with a tube connected to the cyclone's inlet and a tube connected to the dust pump's inlet.

Personal and stationary measurements
Personal measurements are taken by wearing the sampling equipment during a defined task. A cyclone and filter cassette should be placed as near to the breathing zone as possible in order to achieve the best possible representation.

With regard to stationary measurements, the measuring equipment is placed in a defined area, preferably at breathing height. This method is common in preliminary mappings with sampling tests.

Planning and executing a measuring programme must be carried out in close collaboration with the analysis laboratory in order to choose the right analysis methods/types and to order the necessary and prepared test equipment.

3.2 Preparations for testing

Preparing sampler
Test equipment must fulfil the requirements of the European standard NS-EN 481 (ref. 6).

Requirements for test pump:
- Automatic air flow control that keeps the air flow constant even when the underpressure above the filter changes during the testing period, as a result of the dust flow
- Capability to adjust the air flow
- Operating time of at least 12 hours with fully charged battery pack
- Non-pulsating air flow

- Simple assembly/dismantling of the battery pack
- Robust
- Reliable

Equipment for testing respirable dust must contain the following:

- Pump
- Battery pack
- Charger
- Flow meter (rotameter)
- Tube for connecting to pump
- Nipple for transfer between tube and filter cassette
- Filter cassettes/cyclones
- Test form

In addition, where this is not included in the equipment provided, it can be prudent to obtain solid belts for fastening the pump. Likewise, it can also be beneficial to have sports tape available for securing the tubes to the employee's working clothes. This will help prevent the tubes from getting tangled in the equipment and in the work area.

3.3 Practical sampling

The sampling is carried out in four stages:

Preparing the pump

1. Place the filter cassette in the cyclone. Check that the seal is correctly positioned and that the lid of the cyclone is tightened properly. (Leaks must be avoided in order to prevent false air.)
2. Fasten one end of the tube to the pump.
3. Fasten the other end of the tube to the lid of the cyclone.
4. Start the pump and let it run for a while. Check the pump's user manual to see how long it should run before calibration.

Calibration

1. Attach the supplied tube transfer piece to the air inlet on the underside of the cyclone.
2. Attach the meter for the air velocity to the transfer piece.
3. NB. When using a glass rotameter, this must be kept vertical. Read the flow value in the middle of the counter (litres per minute).
4. The air flow should be 2.2 l/min. If not, the test pump must be adjusted so that the air flow is correct. NB: any adjustments to the test pump must be carried out with the cyclone fitted to the tube.

Start sampling

1. Enter important information on the test form, including:
    a. Name of person
    b. Testing location
    c. Start time
    d. Filter number
    e. Flow start (air flow velocity) (l/min)

2. Attach the pump to the employee's back pocket or belt.
3. Attach the cyclone with the test cassette to the employee's shirt collar or as near to the breathing zone as possible.
4. Use sports tape to secure the tubes to the employee's working clothes in order to prevent them getting tangled with other equipment.

Concluding sampling

1. Measure the air flow velocity with the flow meter (rotameter). (See the calibration procedure.)
2. Note the final flow (i.e. the air flow velocity at the end of the testing; measured in l/min) and time on the test form. If the pump has a counter indicating the time, make a note of this.
3. Stop the pump.
4. Note any special conditions surrounding the testing after interviewing the operator. Any damage to the test equipment should be noted, e.g. holes in tubes, damaged cyclone, etc.
5. Remove any rough dust from the cover and replace the cover.
6. Charge the battery packs. The charging procedure must be in accordance with the user instructions for the relevant piece of equipment. (The batteries are normally charged for a minimum of eight hours).
7. Clean the cyclone before the next measurement is taken (use blasted air if necessary).
8. The air volume is calculated by multiplying the average value from flow start and flow finish by the number of minutes of testing. This value can be noted on the test form.

3.4 Test form

A sample test form from the National Institute of Occupational Health (STAMI) is provided in Appendix 1, parts 1 and 2.

3.5 Packing and dispatch of tests

This is carried out in accordance with instructions from the relevant analysis laboratory.

3.6 Analyses

The analyses should be conducted by an approved/accredited laboratory. STAMI and Eurofins Norge are two such laboratories in Norway. The Silica Agreement sets requirements for the analyses of crystalline silica to be conducted using either X-ray diffraction or Fourier-transform-infrared-spectroscopy.

Where amounts are reported that are lower than the detection limit for the analysis, agreement should be reached with the laboratory on how to deal with and use these values.

All measuring results that are related to working environment measurements are stored by the laboratory. The Norwegian Labour Inspection Authority has the right to access measurements that are carried out by approved laboratories in Norway.

4. Reporting/documentation

The exposure evaluation is not complete until a full report has been compiled. The purpose of the report is to document the conditions during the mapping, the measuring results and the evaluations that were carried out in all parts of the process (preliminary evaluation, preliminary study, detailed study, periodic measurements).

The report should contain:
• Name of the company and persons that are responsible for the study
• Name, address and organisation number of the company where the mapping is carried out
• Background and purpose of the study
• Description of the workplace, including process conditions during the testing
• Description of substances and materials that are used, and any intermediate products that are formed
• Where measurements are carried out, describe the following:
  – Testing and analysis methods (including type of equipment/make)
  – When was the equipment calibrated? (calibration certificate)
  – Measuring strategy with reasons for choice of strategy
  – Date and time of measurements
  – Testing period
  – Duration of operations during the testing period
• Name of employee
• Ventilation
• Weather conditions where relevant
• Use of respiratory protective equipment and what type
• Results
• Evaluation of the results, compared with the OEL
• Need for measures
• Brief summary/conclusion

Reports should be easily accessible in the workplace. For purposes of possible future occupational illnesses, the reports should be kept for at least 60 years. See the Norwegian Directive on Chemicals ("Kjemikalieforskriften"), FOR-2001-04-30-443, Section VIII, Register, § 28, last paragraph (ref. 7).

5. Information for employees

It is crucial that everyone who takes part in the testing or who is affected by this in some way, receives the necessary information on the test results and any needs for measures, such as improvements to facilities, modified working methods or use of protective equipment. Information for employees is also important before the mapping begins.

References

1. "Good Practice Guide on Workers' Health Protection through the Good Handling and Use of Crystalline Silica and Products containing it." www.nepsi.eu

2. NS-EN 689: “Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy”
3. NS-EN1232:1997 “Workplace atmospheres. Pumps for personal sampling of chemical agents. Requirements and test methods”
4. Norwegian Labour Inspection Authority order no. 450 ”Kartlegging og vurdering av eksponering for kjemiske stoffer og biologiske forurensninger i arbeidsatmosfære” (Mapping and evaluating exposure to chemical agents and biological contamination in the working atmosphere)
5. Norwegian Labour Inspection Authority no.361 “Administrative normer for forurensning i arbeidsatmosfære.” (Occupational exposure limits for contamination in the working atmosphere)
6. NS-EN 481:1993 ”Working Atmospheres. Size Fraction Definitions for Measurement of Airborne Particles”
7. FOR 2001-04-30 no. 443: Forskrift om vern mot eksponering for kjemikalier på arbeidsplassen (kjemikalieforskriften). (Directive on the protection against exposure to chemicals in the workplace (the chemicals directive))

Appendices

Appendix 1. Test form from the National Institute of Occupational Health (STAMI)