Crystalline Silica

Where does it come from? How is it used in mining?
Crystalline silica is the chemical compound silicon dioxide (SiO_2). Quartz is the most common form of crystalline silica which is found in most rock types including granite, sandstones, quartzites and in sand and soils. Other common forms of silica, crystobalite and tridymite are found in volcanic rocks. All forms may get into the breathing air in sizes that are inhaled into the lung when miners drill, tunnel, and grind these rock types. In mining, the most common exposures underground occur during drilling of rock, transportation of men or material, and loading of mine material. Miners operating equipment such as locomotives, roof bolters, continuous miners, shuttle cars, and other miners working downwind of such equipment also have a potential for exposure to silica.

What are the primary health effects from exposure to Crystalline Silica?
The most common health hazard associated with exposure to crystalline silica is silicosis. Silicosis is a disease of the lungs caused by breathing dust that contains crystalline silica. The silica dust causes irritation and scar tissue to form in the lung which, over time, reduces the lung's ability to deliver oxygen to the blood. Silicosis is classified into three types: chronic or classic, accelerated, and acute. Chronic (classic) silicosis, which is the most common, occurs after 15-20 years of moderate to low exposures to respirable crystalline silica. Accelerated silicosis can occur after 5-10 years of high exposures to respirable crystalline silica. Acute silicosis occurs after a few months or as long as 2 years following exposures to extremely high concentrations of respirable crystalline silica. Silicosis causes shortness of breath, weakness, increased lung infections, chest pain, and eventual death. Silica is also a potential carcinogen.

What are the occupational exposure limits for Crystalline Silica?
Current MSHA standards limit exposures to crystalline silica (quartz) in dust. For the coal mining industry, the standard is based on dust permissible exposure limit of 2 mg/m^3 though the standard is changed to a of formula 10 mg/m^3 divided by the percentage of quartz if the quartz concentration in the dust is greater than 5%. For the metal and nonmetal mining industry, the standard is based on the 1973 American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) formula: 10 mg/m^3 divided by the percentage of quartz plus 2. Both formulas limit exposures to 0.1 mg/m^3 of silica.

While not required by the Mining Safety and Health Administration, it is highly recommended to comply with the most current recommended airborne concentration guidelines. The 2011 ACGIH TLV for crystalline silica as quartz and cristobalite is 0.025 mg/m^3 for an 8-hour time-weighted average-minute period with an "R" notation. The "R" means that the sampling must be for "respirable particles" or those that can be inhaled deep into the lung. Respirable particle sampling must be done with a special sampling tool called a cyclone that limits the air sampling to dusts that are a specific size (less than 4 microns). The Immediately Dangerous to Life and Health (IDLH) concentration (the level that can cause immediate death) is 50 mg/m^3.

How often shall I complete exposure monitoring for Crystalline Silica?
Silica is found in nearly all rock types; therefore, it is important for all mine operators to complete air sampling for silica. 30 CFR Part 56.5002 requires that dust, mist, and fume surveys be conducted *as frequently as necessary* to determine the adequacy of control measures. It is standard practice to sample initially (called a baseline evaluation) to determine potential exposure concentrations. Routine or periodic monitoring (usually annually) is also recommended. Sampling may need to be done more often if the tasks change, if the engineering controls change, or if sampling results are above the "action limit" which, for most chemicals, is defined as 50% (or half) of the TLV.

How do I measure potential exposure to Crystalline Silica?
To measure worker exposure to crystalline silica, air sampling should be completed for the entire shift to compare with standards and guidelines. NIOSH Method 7500, the recommended sampling method for crystalline silica, uses a cyclone (10-mm nylon, Higgins-Dewell (HD), or aluminum) with a 0.5 micron polyvinyl chloride filter for media. The flow rate of the air sampling pump is set at 1.7 (nylon cyclone), 2.2 (HD cyclone), or 2.5 liters of air per minute

(aluminum cyclone) and the acceptable volume for each filter is 400 – 800 liters of air. Analysis is performed by x-ray powder diffraction by a certified laboratory. The air sampling pump must be calibrated with the cyclone on the filter which is done by using a calibration jar for nylon and HD cyclones and a calibration sheath for aluminum cyclones.

Once the laboratory provides you with the mass of crystalline silica in milligrams measured on the filter, you can calculate the air concentration as: C = M / Q x T where C is the concentration of crystalline silica in mg/m^3, M is the mass of crystalline silica measured on the filter/in the solution in mg, Q is the pump flow rate in liters per minute and T is the total time of sampling in minutes. The laboratory may report the crystalline silica as "quartz", "crystobalite" and "tridymite". The calculation can be done separately for each type of silica. Note that many laboratories will do this calculation for you if you provide the flow rate and total sample time or the sample volume on your chain of custody. Many laboratories will also loan you the necessary equipment to obtain the samples and provide you with the filters. Certified laboratories that can assist with measuring crystalline silica include: Galson http://www.galsonlabs.com/ or Analytics Corporation http://www.analyticscorp.com/.

How do I control exposures to Crystalline Silica?

30 CFR Part 56.5005 requires the control of employee exposures to harmful airborne contaminants, by prevention of contamination, removal by exhaust ventilation, or by dilution with uncontaminated air. The standard allows for respiratory protection when accepted engineering control measures have not been developed or when necessary by the nature of the work involved. The following table may be helpful when selecting a respirator for silica.

Concentration (mg/m^3)	APF	Respirator
0.5	10	air-purifying with a HEPA filter or supplied-air
1.25	25	supplied-air operated in continuous-flow mode or powered air-purifying with a HEPA filter
2.5	50	air-purifying full-face piece with a HEPA filter, supplied-air with tight-fitting face piece operated in continuous-flow mode, powered air-purifying with tight-fitting face piece and a HEPA filter, self-contained breathing apparatus with full face piece, or supplied-air with full face piece
25	1000	supplied-air operated in pressure-demand or other positive-pressure mode
Unknown or IDLH	10000	supplied-air with full face piece operated in a pressure-demand or other positive-pressure mode and in combination with an auxiliary self-contained positive-pressure breathing apparatus (SCBA)

Mine operators are required to provide and assure the maintenance and use of controls for dust while drilling in rock. Miners should use all available engineering controls such as dust collectors, wet drilling, and adequate ventilation. Roof bolter operators and helpers are encouraged to either bag the dust from dry dust collection boxes and place it into the return or shovel the dust from the box against the ribs to prevent re-suspension of the dust during normal mining activities. Miner operators can reduce the amount of silica-containing dust generated by staying in-seam while mining. Cutting sandstone top and/or bottom while mining generates excessive amounts of silica-containing dust. Mining and bolting should be completed on cycle, to limit the number of times the roof bolter works downwind.

References:

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