MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

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To: File for Crystalline Silica (CAS No. 14808-60-7)

From: Michael Depa, Air Quality Division, Toxics Unit

Subject: Screening Level

The Initial Threshold Screening Level for crystalline silica is 3 µg/m^3, with an annual averaging time. This ITSL applies to quartz (CAS No. 14808-60-7) and three polymorphs: cristobalite (CAS No. 14464-46-1), tridymite (CAS No. 15468-32-3) and tripoli (CAS No. 1317-95-9).

Note that, pursuant to Rule 120(f), crystalline silica is exempt from the definition of a toxic air contaminant under certain conditions. The relevant part of this rule is as follows:

> [T]he flowing substances shall not be considered to be toxic air contaminants:
> (xv) Crystalline silica emissions from any of the following processes:
> (A) Extraction and processing of all metallic or non-metallic minerals.
> (B) Sand production, processing, and drying.
> (C) Asphalt production.
> (D) Concrete production.
> (E) Glass and fiberglass manufacturing.
> (F) Foundries.
> (G) Foundry residual recovery activities.
> (H) Any other process if the crystalline silica emissions are less than 10% of the total PM-10 emissions.

Only those sources of crystalline silica that are not exempt would be required to comply with Rule 225(1).

In 1996, the Air Quality Division's Scientific Advisory Panel (SAP), made up of scientists from both industry and academia, evaluated the epidemiological and toxicological database and published a report on their findings (SAP, 1996). The Panel found that the weight of evidence indicated that silicosis is a likely precursor to lung cancer; therefore, a health benchmark that is protective for silicosis is protective for lung cancer. The SAP (1996) stated:

> Observations in humans show the presence of silicosis when lung tumors are observed. In other words, there is abundant information that exposures to crystalline silica can result in silicosis, and that sometimes silicosis is accompanied by lung tumors. No evidence was uncovered that these lung tumors have occurred without the presence of fibrosis or silicosis.

In order to review the most up to date information on silica health standards, the following literature was searched and/or evaluated:

US Environmental Protection Agency (US EPA)
Agency for Toxic Substances and Disease Registry (ATSDR)
Texas Commission on Environmental Quality (TCEQ)
California Office of Environmental Health Hazard Assessment (Cal OEHHA)
Wisconsin Department of Natural Resources (WDNR)
American Conference of Governmental and Industrial Hygienists (ACGIH)
Registry of Toxic Effects of Chemical Substances (RTECS)
Hazardous Substances Data Bank (HSDB) Toxnet
European Chemical Agency (ECHA)
Google (search terms: silica health benchmark standard exposure limit)

Wisconsin published a comprehensive review of state and federal agency health benchmarks (WDNR, 2011), including the results of a state survey and personal contact information.

Most state, national and international governmental organizations have established occupational exposure limits (OELs) for silica; however, OELs often do not explicitly protect sensitive individuals (e.g., children, elderly, infirm). Health protective exposure limits designed to protect sensitive individuals were preferentially selected for further review. Using this criteria, two health benchmarks were identified:

1. Reference Exposure Limit (REL) of 3 µg/m³ (PM4) by Cal OEHHA (2005)
2. Reference Value (ReV) of 2 µg/m³ (PM4) by TCEQ (2009)

Where PM4 stands for particle sizes that are ≤ 4 micrometers (µm) aerodynamic diameter.

Both the Cal OEHHA and TCEQ developed their health benchmarks to prevent silicosis and both were based on data obtained from an epidemiology study published by Hnizdo and Sluis-Cremer (1993). In this study, the authors found that increasing cumulative dust exposure (CDE) and radiological evidence of silicosis in South African gold miners were highly correlated. The dose-response data from Hnizdo and Sluis-Cremer (1993) were fit to a curve using US EPA Benchmark Dose Software (BMDS) in order to derive the 95% lower bound on the Benchmark Concentration at 1% extra risk ($BMCL_{01}$). Hnizdo and Sluis-Cremer (1993) measured 30% crystalline silica content in the dust. A re-evaluation of quartz content was performed by Gibbs and Du Toitt (2002) which found that the % quartz is better approximated by 54%. Both Cal OEHHA and TCEQ adjusted the CDE measurements to account for 54% silica, however, Cal OEHHA adjusted the dose measurement before running the BMDS, and TCEQ adjusted the dose after running BMDS. It is not clear how running the BMDS with different exposure levels resulted in nearly identical $BMCL_{01}$ values (see Table 1). If input parameters and BMDS settings were constant then the $BMCL_{01}$ should differ by 14% (54%-30%). Table 1 shows the intermediate values used to derive the health benchmarks.

Note that the California health exposure limit used a 24-year exposure duration, which was the average exposure duration of the subjects in the Hnizdo and Sluis-Cremer (1993) study.

Table 1. Derivation Steps to Calculate Health Benchmark for Crystalline Silica

	Cal OEHHA	TCEQ
$BMCL_{01}$	0.636 mg/m³ - year	0.635 mg/m³ - year
Continuous daily adjustment [1]	10m³/20m³	10m³/20m³
Continuous yearly adjustment [2]	270days/365days	270days/365days
Chronic duration adjustment	24 years	70 years
Crystalline silica % adjustment	— [3]	54%/30%
Human Equivalent Concentration	9.8 µg/m³	6.04 µg/m³
Uncertainty factor [4]	3	3
Health Benchmark	3 µg/m³	2 µg/m³

[1] 8-hour occupational respiratory rate = 10m³; 24-hr daily respiratory rate = 20m³
[2] number of days worked per year / number of days per year
[3] Cal OEHHA apparently made the % crystalline silica adjustment prior to running the benchmark dose software.
[4] For sensitive individuals

This differs from the TCEQ chronic adjustment in that Texas adjusted the exposure concentration to account for a 70 year life. Because Cal OEHHA developed a REL using an exposure metric (mg/m3 – years) that was converted to an air concentration based on the actual duration of exposure of South African gold miners (24 years) it was deemed more appropriate to use than the TCEQ value. Therefore, the ITSL is based on the Cal OEHHA reference value (ReV) of 3 µg/m³, and given an annual averaging time.

It is appropriate to apply the ITSL to PM4 rather than PM10. Crystalline silica particle exposures measured as PM4 more closely approximate the exposure dose from the key study (Hnizdo and Sluis-Cremer, 1993). The ITSL may also be applied to PM10 crystalline silica if that is the form of the available emissions (or ambient air) data, with a caveat that doing so introduces some conservatism to the assessment.

References

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