APPENDIX J

SAMPLE CALCULATIONS FOR CRYSTALLINE SILICA

Reference Formulas

A. Construction/Maritime PEL for Crystalline Silica (Quartz) (using Equation 5 from Section III.K.2.):

$$PEL\ (crystalline\ silica, quartz) = \frac{250\ mppcf}{\%\ silica + 5}$$

B. General Industry PEL for Crystalline Silica (Quartz) (using Equation 6 from Section III.K.2.):

$$PEL\ (mg/m^3) = \frac{10\ mg/m^3}{2 + \%\ respirable\ quartz}$$

C. OSHA-adopted conversion factor:

$$1\ mppcf = 0.1\ mg/m^3\ respirable\ dust \qquad or$$

$$1\ mg/m^3 = 10\ mppcf\ respirable\ dust$$

D. Combining multiple silica samples (single analyte) with different percentages and mass:

$$Recalculated\ \% = \frac{(Pa\ x\ Wa) + (Pb\ x\ Wb)}{Wa + Wb}$$

Where:

P = Lab reported percentage of silica for each sample
W = Mass of silica reported by the lab for each sample

Example 1: Two consecutive samples were collected to monitor the same employee for a combined exposure to silica dusts for one work shift. The analytical results are shown in Table J-1, Sample Silica Exposure Data.

Table J-1
SAMPLE SILICA EXPOSURE DATA

Sample	Sampling period (min)	Total volume (L)	Respirable weight (mg)	Respirable concentration (mg/m^3)	SLTC results (%)
A	238	405	0.855	2.1	5.2 quartz 2.3 cristobalite ND tridymite
B	192	326	0.619	1.9	4.8 quartz 1.7 cristobalite ND tridymite
Total	430	731	1.474		
Key: ND = Not detectable.					

Calculation of the TWA from the sampling and analytical data:

Step 1. Calculate the percentage of quartz, cristobalite, and tridymite in the respirable particulate collected (using Equation 8 from Section III.K.2.).

$$Quartz: 5.2\left(\frac{0.855}{1.474}\right) + 4.8\left(\frac{0.619}{1.474}\right) = 3.0 + 2.0 = 5.0\%$$

$$Cristobalite: 2.3\left(\frac{0.855}{1.474}\right) + 1.7\left(\frac{0.619}{1.474}\right) = 1.3 + 0.7 = 2.0\%$$

Step 2. Calculate the PEL for the mixture (using Equation 12 from Section III.K.2.):

$$PEL_{mixture} = \frac{10\ mg/m^3}{\%\ quartz + 2(\%\ cristobalite) + 2(\%\ tridymite) + 2}$$

$$= \frac{10}{5.0 + 2(2.0) + 2(0) + 2} = \frac{10}{11.0} = 0.91\ mg/m^3$$

Step 3. Calculate the employee's exposure (using Equation 7 from Section III.K.2.). NOTE: 1L = 0.001 m^3

Equation J-1

$$Exposure = \frac{Sample\ wt.\ A + Sample\ wt.\ B}{Total\ Volume} = \frac{0.855 + 0.619}{0.731} = 2.0\ mg/m^3$$

Step 4. Adjust (where necessary) for less than 8-hour sampling period.

Equation J-2

$$TWA = (2.0\ mg/m^3)\frac{430\ min}{480\ min} = 1.8\ mg/m^3$$

Step 5. Calculate the severity of the exposure (using Equation 9 from Section III.K.2.):

$$\frac{1.8\ mg/m^3}{0.91\ mg/m^3} = 2.0$$

After Step 5, the upper and lower confidence limits would be determined by applying the SAE as described in Section IV.D. of this document, and as shown in Examples 2 and 3 below.

Example 2: A sample is obtained for a construction jackhammer operator using the gravimetric sampling method specified in OSHA Method ID-142. The sample is run for 240 minutes at a flow rate of 1.7 L/min, yielding a total sample volume of 0.408 m^3. The respirable dust collected on the filter is

determined to weigh 0.857 mg, resulting in a respirable dust concentration of 2.1 mg/m^3. The SLTC reports that the sample contains 55% quartz. The SLTC also reports an SAE of 0.20 for the sample.

Step1. Determine the jackhammer operator's 8-hour TWA respirable dust exposure (assuming zero exposure for the unsampled portion of the 8-hour shift) (using Equation J-2):

$$Exposure = 2.1\ mg/m^3\ x \frac{240\ min}{480\ min} = 1.05\ mg/m^3\ respirable\ dust$$

Step 2. Calculate the general industry PEL, assuming the conditions for the jackhammer operator sample containing 55% respirable quartz (using Equation 12 from Section III.K.2.):

$$PEL\ (mg/m^3) = \frac{10\ mg/m^3}{2 + 55} = 0.175\ mg/m^3$$

Step 3. Calculate the Severity Ratio (using Equation 9 from Section III.K.2.):

$$Severity = \frac{sample\ results\ (from\ Step\ 1)}{calculated\ PEL\ (from\ Step\ 2)} = \frac{1.05\ mg/m^3}{0.175\ mg/m^3} = 6.0$$

Step 4. Calculate confidence limits by applying the SAE (Equations 10 and 11 respectively, from Section III.K.2):

$$Lower\ Confidence\ Limit\ (LCL) = 6.0 - 0.20 = 5.8$$

$$Upper\ Confidence\ Limit\ (UCL) = 6.0 + 0.2 = 6.2$$

Step 5. Based on a confidence limit of 5.8, the sample exceeds the 95% confidence limit for overexposure.

Step 6. Apply the OSHA-adopted conversion factor (using Equation 4 from Section III.K.2.) to the jackhammer operator's exposure result from Step 1 and Reference Formula (B) above:

$$Exposure = (1.05\ mg/m^3)\frac{1\ mppcf}{0.1\ mg/m^3} = 10.5\ mppcf$$

Step 7. Calculate the applicable construction PEL for jackhammer operator sample containing 55% respirable quartz (using Equation 5 from Section III.K.2.):

$$PEL = \frac{250\ mppcf}{55\% + 5} = 4.17\ mppcf$$

Step 8. Conclusion. The 8-hour TWA exposure of the jackhammer operator exceeds the construction industry PEL for crystalline silica (quartz).

Example 3: Two samples are obtained for a construction foreman overseeing a concrete drill press operation. Both samples are collected at a flow rate of 1.7 L/min. The duration of Sample A is 238 minutes, yielding a total sample volume of 0.40 m^3. The respirable dust collected on the filter is

determined to weigh 0.855 mg, resulting in a respirable dust concentration of 2.1 mg/m^3. The SLTC laboratory reports that Sample A contains 30% quartz. The duration of Sample B is 192 minutes, yielding a total sample volume of 0.326 m^3. The respirable dust weight is 0.619 mg, resulting in a concentration of 1.9 mg/m^3. The total weight of respirable dust collected on both samples is 1.474 mg. The SLTC laboratory reports that Sample B contains 25% quartz. The SLTC reports an SAE of 0.16 for both samples.

Step 1. Determine the foreman's 8-hour TWA respirable dust exposure (using Equation 13 from Section IV.D.4.):

$$Exposure = \frac{(2.1\ mg/m^3 \times 238\ min) + (1.9\ mg/m^3 \times 192\ \text{min})}{480\ min} = 1.8\ mg/m^3$$

Step 2. Determine average quartz content since the SLTC provided two different percentages of quartz, using Reference Formula D, above:

$$Recalculated\ \% = \frac{(30\%\ x\ 0.855) + (25\%\ x\ 0.619)}{(0.855 + 0.619)} = 28\%$$

Step 3. Calculate the general industry PEL, assuming the conditions for the construction foreman sample containing 28% respirable quartz (using Equation 12 from Section III.K.2):

$$PEL(mg/m^3) = \frac{10\ mg/m^3}{2 + 28} = 0.333\ mg/m^3$$

Step 4. Calculate the Severity Ratio (using Equation 9 from Section III.K.2):

$$Severity = \frac{1.8\ mg/m^3}{0.333\ mg/m^3} = 5.4$$

Step 5. Calculate confidence limits by applying the SAE (using Equations 10 and 11 respectively, from Section III.K.2):

$$LCL = 5.4 - 0.16 = 5.24$$

$$UCL = 5.4 + 0.16 = 5.56$$

Step 6. Based on a severity of 5.4, the sample exceeds the 95% confidence limit for overexposure.

Step 7. Apply the OSHA-adopted conversion factor to the construction foreman's exposure result from Step 1 and Reference Formula C above (using Equation 4 from Section III.K.2.):

$$Exposure = (1.8\ mg/m^3)\frac{1.0\ mppcf}{0.1\ mg/m^3} = 18.0\ mppcf$$

Step 8. Calculate the applicable construction PEL, (using Equation 5 from Section III.K.2.) for the foreman's samples containing an average of 28% respirable quartz:

$$PEL = \frac{250\ mppcf}{28 + 5} = 7.58\ mppcf$$

Step 9. Conclusion. The eight
-hour TWA exposure of the foreman exceeds the construction industry PEL for crystalline silica (quartz).