

UNDERSTANDING THE OSHA SILICA STANDARD FOR CONSTRUCTION – REAL-TIME MONITORING FOR RESPIRABLE SILICA DUST

APPLICATION NOTE EXPMN-024 (US)

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Introduction

The Occupational Safety and Health Association (OSHA) has implemented a new ruling on the permissible exposure limit (PEL) for respirable crystalline silica dust that sets the limit to 50 µg/m³, averaged over a continuous 8-hour shift. This is 50% below the previous levels and has put the spotlight on the seriousness of respirable silica exposure in the construction industry.

The purpose of this document is to introduce the advantages of real-time monitoring into the process of reducing respirable silica exposure in the construction industry. This guide is for general information only and does not supersede the OSHA silica standard or guarantee compliance.

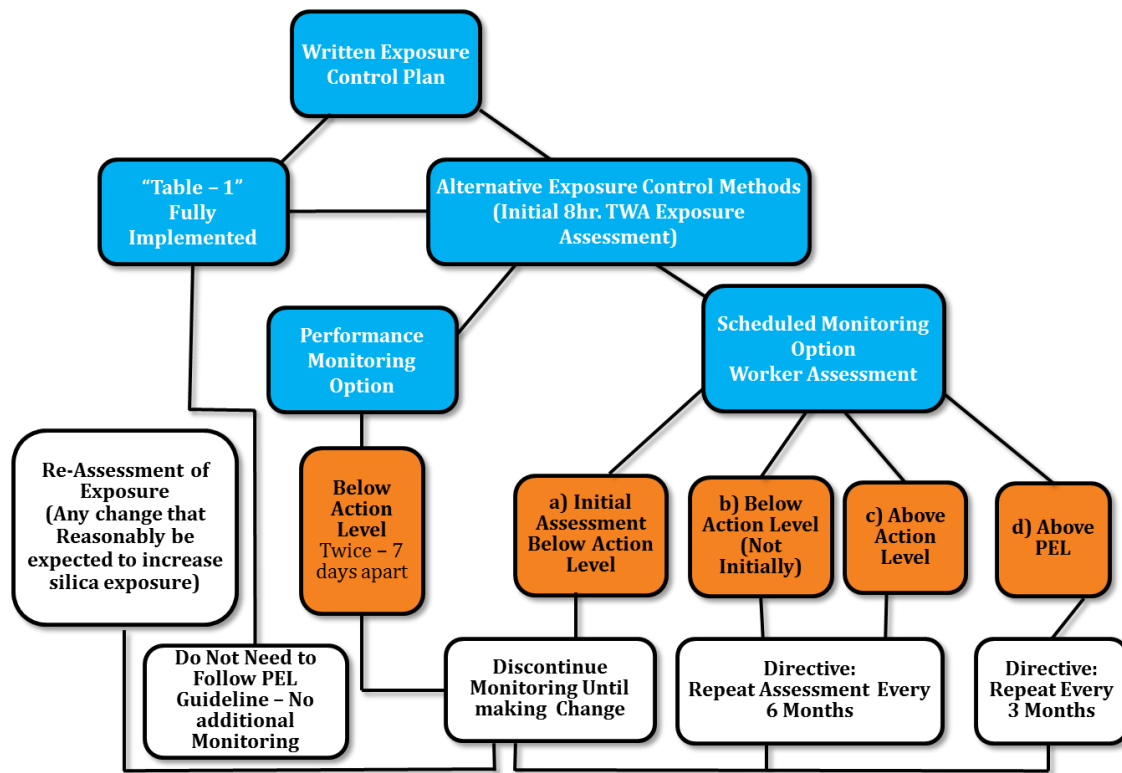
When establishing the new rule, OSHA structured compliance to the ruling in three parts as noted below, with each having an assigned date for compliance:

- **Construction:** September 23, 2017
- **General Industry & Maritime:** June 23, 2018
- **Hydraulic Fracturing:** June 23, 2020

To help companies comply with the new standard by this date, OSHA includes guidance throughout the published standard regarding actions employers must take to protect workers from excessive silica exposure.

Below is a simple flow diagram of the pathway for silica exposure control options within the OSHA silica standard. Table-1 of the standard covers many of the tasks where exposure to silica dust is expected. If an employer cannot (or chooses not to) follow Table-1, or for tasks that are not within Table-1, the standard provides Alternative Exposure Control Methods to follow. This will be covered in more detail later in this discussion.

New Silica Rule—Roadmap of Exposure Control Methods



The new standard contains specific guidance in the form of Table-1 for construction tasks. This table specifies engineering controls, location for performing tasks, the duration of the tasks and the use of respirators (PPE). If an employer fully and properly implements Table-1, they are not subject to the PEL and no further exposure monitoring is required.

Any work task not included on Table-1 (or where the employer chooses to not fully and properly implement the required engineering controls, work practices or respiratory protection), the employer is required to follow one of the alternative exposure control methods to keep respirable silica exposure below the PEL limit of $50 \mu\text{m}/\text{m}^3$ as a TWA over an 8-hour shift.

There are two types of alternative exposure control methods that an employer can follow (reviewed at full length later in this document). When using either of these alternative methods, an employer is required to measure worker exposure to the new action level of $25 \mu\text{g}/\text{m}^3$ TWA over an 8-hour shift. If silica exposure is above the action level, OSHA requires repeated, frequent personal exposure monitoring in addition to implementation of workplace controls, engineering controls or the use of personal protection devices. This is also true in select cases when the silica exposure was lowered below the action level after the initial assessment showed exposure above $25 \mu\text{g}/\text{m}^3$ TWA.

When calibrated to represent respirable silica dust levels, real-time instruments can help employers successfully navigate the requirements of the new silica exposure standard. Real-time instruments allow for rapid response to high silica exposure environments, faster validation of corrective actions and provide more data for in-depth insights into the silica exposure within an operation. This document is a primer on how direct reading instruments can help companies save time and reduce costs while working to reach and maintain compliance to the OSHA silica standard.

OSHA has created several supporting documents, guides and FAQs about the new standards available online at www.osha.gov/silica.

Silica Dust in Construction

The construction industry has the largest number of workers that are potentially exposed to high levels of crystalline silica. OSHA estimates 2.3 million workers are potentially exposed to crystalline silica in the workplace with 90% of those being employed in the construction industry.

Respirable silica dust is considered a carcinogen by the Center for Disease Control (CDC). OSHA advises it to be treated as hazardous in an airborne state. Because of the small size of respirable particles, once silica gets into the deep part of the lungs, it cannot be removed or expelled.

Silica is found in both natural and man-made substances. It is existent in three types: quartz (most common), cristobalite and tridymite. Materials including sand, concrete, brick, concrete block, stone, sheet rock, tile, grout and mortar all contain one of the above types of crystalline silica.

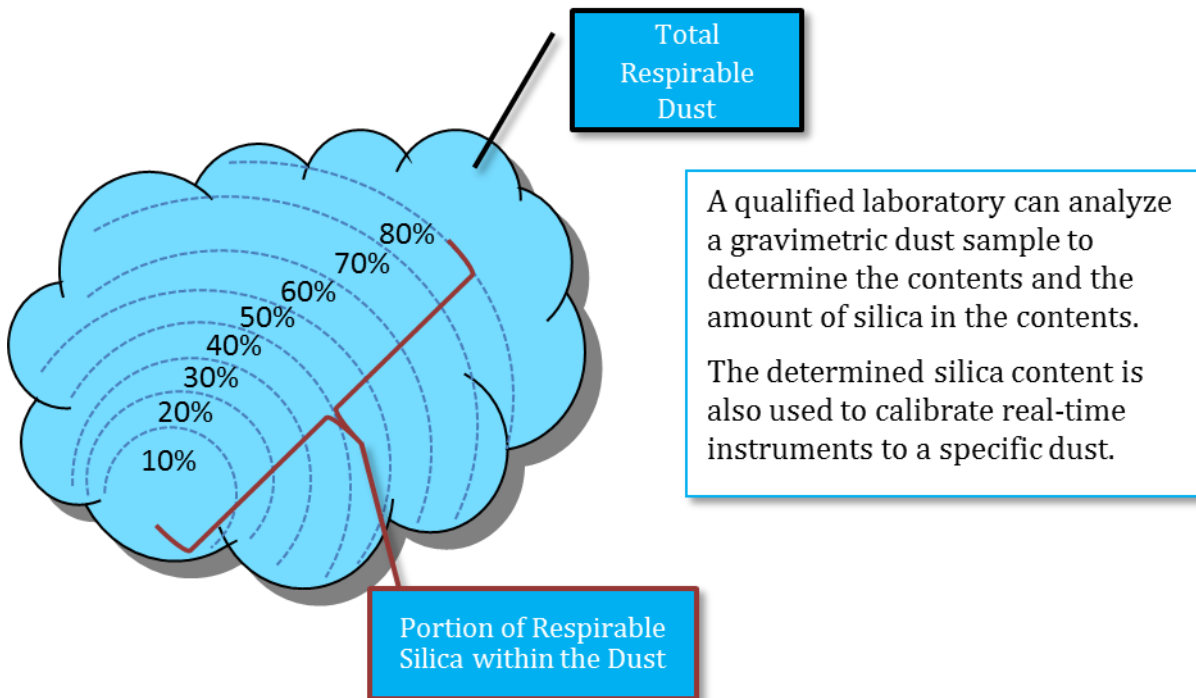
Respirable crystalline silica is created by any high-energy operation such as cutting, sanding, sawing, grinding, polishing, drilling and crushing stone, rock, concrete, brick, block and mortar. Other activities such as sand blasting, sweeping dirty areas, using compressed air to clean, driving or operating heavy equipment on dirt roads, the demolition of structures or transferring dry materials containing silica also create respirable silica.

The Difference between Inhalable, Respirable and Respirable Silica Dust

Airborne particles which can enter the nose and mouth during normal breathing. Particles of 100 μm in diameter or less. Larger particles will usually not get past the nose and throat and can be expelled naturally.

| | |
|---|---|
| Thoracic Dust | Particles that will pass through the nose and throat, reaching the lungs. Particles of 10 μm diameter and smaller are considered thoracic sized particles. Commonly referred to as PM_{10} . |
| Respirable Dust | Respirable dust particles smaller than 4 μm will penetrate into the gas exchange region of the lungs and as a result, are considered hazardous. Respirable dust are small particles at least 100 times smaller than white beach sand and are too small to be visible in the air. These particles are small enough to get into the deepest part of the lungs and cannot be expelled. |
| Respirable Crystalline Silica Dust | Respirable silica particles are 4 μm or smaller in size and make up only part of the total respirable dust. |

Most construction materials contain elements other than silica. Silica typically makes up only an unknown portion of respirable dust depending on the material being used. Real-time direct reading instruments from TSI can be calibrated to calculate the representative level of silica content of dust being measured, providing users with a valuable approximation level of respirable silica dust exposure in real time.



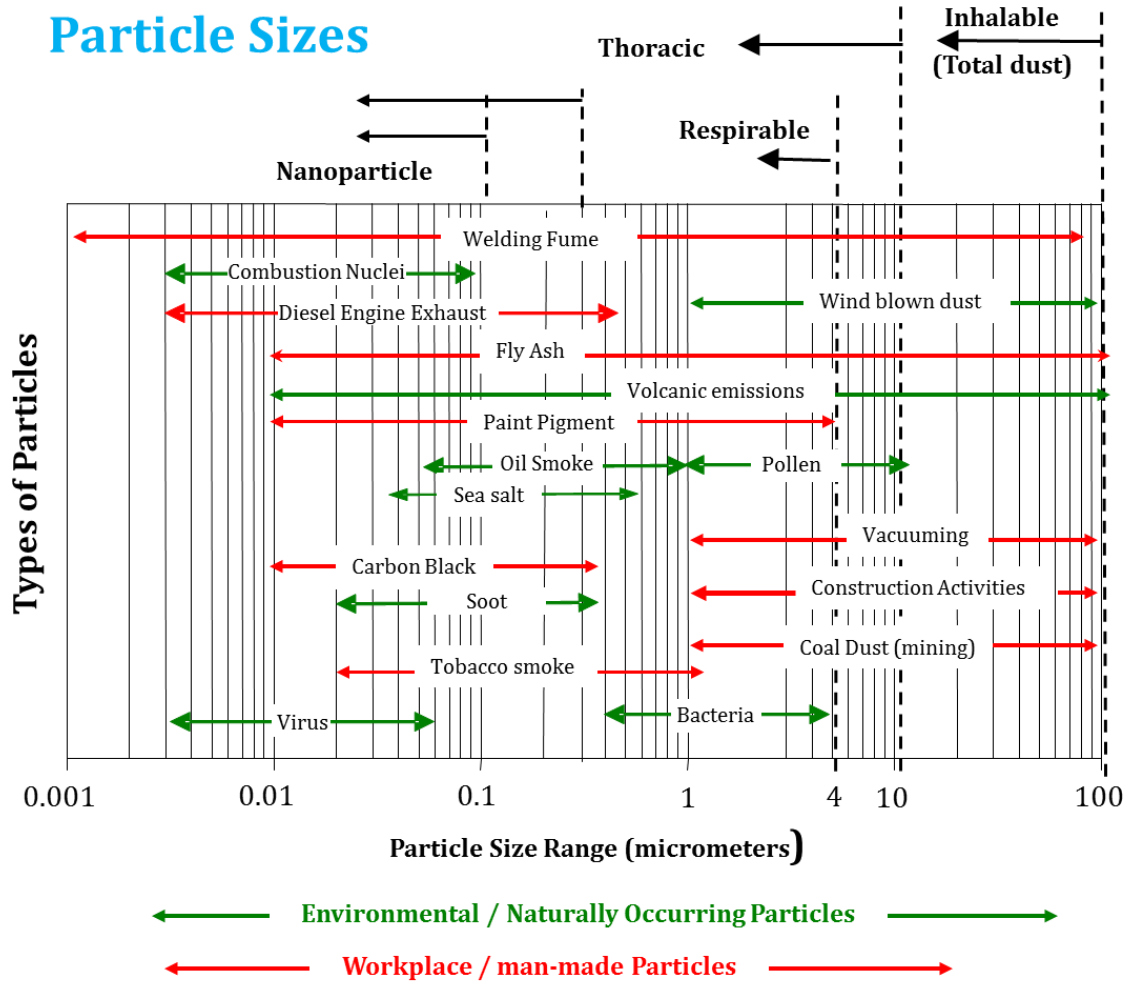
Airborne dust particles visible to the eye are much too large to be considered respirable. These larger particles typically drop out of the air quickly due to their weight and are not airborne for long. The human eye can generally see particles larger than $40\text{ }\mu\text{m}$ or 0.04 mm or roughly 10 times larger than what is defined as respirable. When inhaled, the larger particles get caught in the nose and throat and can be expelled.

Respirable dust contains particles that are too small to see and which stay aloft in the air for extended periods. This is part of what makes them difficult to manage. OSHA recommends that workers do not rely only on visible dust particles to assess the presence of potential silica hazard. Even when the air appears clear the presence of respirable dust is often detectable by instrumentation.

It is important to note that total respirable dust is not all silica. Silica is typically found as a percentage of the total dust. The exception to this is if the material being worked on is 100% quartz or one of the other types of silica. The OSHA standard is focused on the exposure level of respirable silica to construction workers.

The graphic below provides a good perspective for the various particle sizes of measureable dust.

Particle Sizes



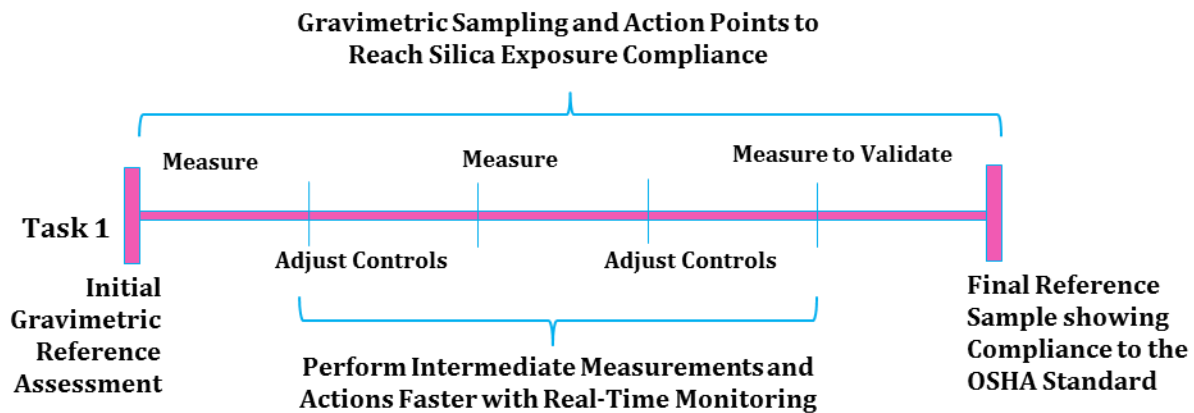
Silica Dust Measurement in Real Time

When following one of the alternative methods of the standard to reach and maintain compliance, real-time monitoring offers many advantages.

Lab analysis of gravimetric samples are required to document respirable silica levels and are used as reference in the final determination that silica exposure levels are in compliance to the OSHA standard. Dust sampling is done throughout the process of measurement, adjustment (or implementation) of engineering controls and further measurements to validate the effectiveness of any changes. Using only gravimetric sampling, this process can take weeks or even months to complete and are often repeated as required by the standard.

Real-time sampling can save time and money being used at varying stages between gravimetric sampling. Gravimetric sampling is required at the initial assessment to understand the existing level of silica exposure. Once the lab analysis is complete and it is determined if levels are above the PEL or action Level, corrective action(s) can be identified. This information is also valuable for calibrating real-time instruments to represent silica levels directly (more on this later).

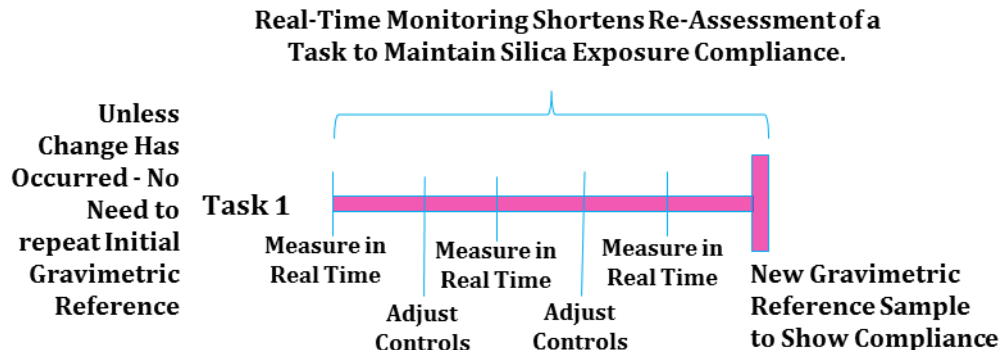
The graphic below is an example of an assessment process and steps where gravimetric samples would be required to reach compliance.



It is important to note that the use of real-time instruments will not totally replace the need for gravimetric sampling; however, real-time monitoring can minimize the number of gravimetric samples taken. As stated earlier, gravimetric sampling is needed as a reference measurement at the beginning and again at the end of an initial exposure assessment as well as when completing follow-up assessments in order to prove compliance.

The value and power of real-time monitoring is the ability to reduce the number of gravimetric samples and provide fast access to actionable data. This compresses the time and eliminates the considerable expense of taking silica exposure measurements, taking corrective actions when needed and then validating the effectiveness of the actions.

The graphic below shows how a follow-up assessment cycle can be shortened and completed more efficiently with real-time monitoring.



Gravimetric samples take time to collect, cost money for labs to analyze and extend the time taken to implement corrective actions due to the lag time in receiving the reports from the lab. Until the reports are sent back to the company and reviewed, gravimetric samples do not reveal useful employee exposure information in a timely manner. Real-time monitoring provides instant exposure data and eliminates the waiting time for lab analysis.

Additionally, when following the Alternative Control Methods as outlined in the OSHA rule, companies are required to reassess the exposure level of a task with described frequency to maintain compliance to the standard. Real-time direct reading instruments will shorten the time to get actionable data when doing reassessments and when validating adjustments to engineering controls.

The OSHA silica standard also requires exposure reassessment anytime a material, process or equipment change has been made and could potentially change a workers exposure to respirable silica. If the material has changed, a new gravimetric sample is required.

If the material is the same, real-time dust monitoring can provide construction companies with a fast, low cost, easy-to-use tool for performing reassessments at any time. The ability for employers to measure dust (aerosol) concentration levels in real-time during a work shift can dramatically speed up the implementation, adjustments and validation of engineering controls. In addition to significant time and cost savings while validating compliance with the OSHA standard, employers gain confidence that silica exposure levels are under control prior to performing a final gravimetric sample to show compliance.



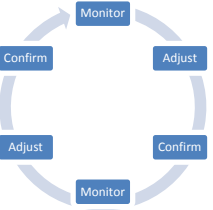
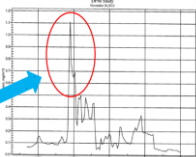

The power of real-time measurements has been demonstrated over the years. OSHA supports the use of real-time direct reading instruments, making the following statement:

OSHA Compliance Guide to the Silica Standard:

“Employers can use direct-reading instruments to measure real-time levels of respirable dust in the air. If the employer has information on the percentage of respirable crystalline silica in that dust”

Advantages of Real-Time Direct Reading Instruments

Regardless of the OSHA exposure control method used, maintaining compliance with real-time dust monitoring instruments from TSI can provide many real-time advantages:

| | |
|---|---|
|  | <ul style="list-style-type: none"> • Reduced Set-up and Sample Collection Times. Immediately displays and logs representative measurements in less time than traditional gravimetric sampling. • Fast Corrective Action. Achieve in hours or days to get the results that typically takes weeks or even months to complete using only gravimetric sampling. |
|  | <ul style="list-style-type: none"> • Instant Alerts and Exposure Data. Provides immediate results to base decisions and take corrective actions as well as to validate those actions for effectiveness so further adjustments can be made. |
|  | <ul style="list-style-type: none"> • Frequent, Affordable and Repetitive. Allows for efficient sampling that is required by several sections of the OSHA silica standard. • Easy Maintenance. Provides the ability to perform assessments at any time, ensuring compliance is always maintained. |
|  | <ul style="list-style-type: none"> • Real-Time Data Logging. Provides employers with an exposure data trail of employee silica exposure levels—data during alarm conditions can be analyzed through a review of the graphs and data through easy report generation |
|  | <ul style="list-style-type: none"> • Reduction in Worker Risk. Reduce risk to workers, reduce costs per sample and reduce the risk to companies by way of real-time dust monitoring. • Confidence on the Path to Compliance. Provides employers with a high level of confidence that silica exposure levels are within compliance before final gravimetric reference samples are taken. |

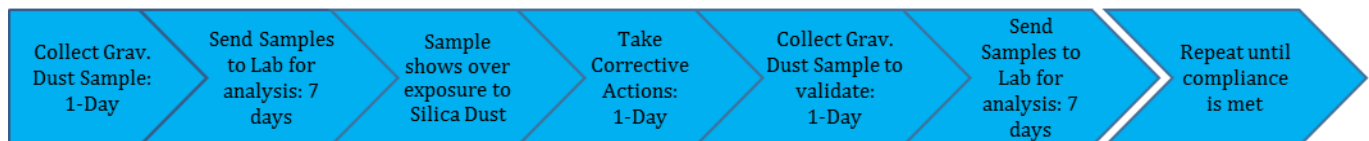
Time-Line Comparison of Gravimetric Sampling vs. Real-Time Monitoring

To further demonstrate the advantages of real-time dust monitoring, consider the graphic below. It illustrates an example of a short monitoring process that requires the following: initial analysis of silica exposure, corrective actions to be taken, validation of those actions, an additional adjustment to controls and the final confirmation of reduced silica exposure. An actual case may take several more (or fewer) adjustment cycles with verification to ensure that exposure levels have been mitigated and meet compliance standards under the new OSHA rule.

Example of Reassessing a Task with an Adjustment to Engineering Controls (assumes real-time instrument has correct calibration factor)

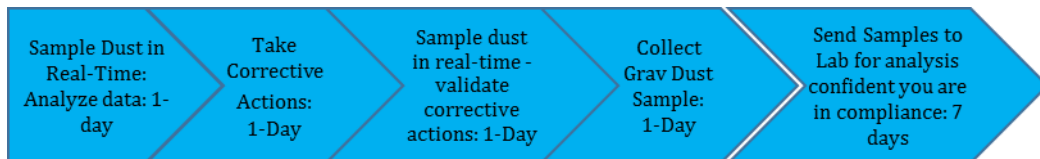
Gravimetric Sample Process:

Two rounds of sampling to prove compliance – **Total 26+ days:**



Real-Time Monitoring Process:

Two rounds of sampling to prove compliance – **Total 13 days:**



In this example, real-time dust monitoring shows a 50% time savings over air sampling with gravimetric analysis. Additionally, an internal TSI analysis has shown cost savings up to 53% for processing just five studies with ten samples each.*

Simply put, real-time silica dust monitoring allows employers to do in days, what typically would take weeks or even months to achieve using gravimetric sampling—at far less cost.

Notes: Example above assumes two rounds of sampling to correct exposure and prove compliance—depending on many variables—additional sampling rounds will likely be required.

* Based on TSI internal documents.

The OSHA Standard and TSI Real-Time Monitoring Solutions

Achieving and maintaining compliance to the new OSHA standard for respirable silica contains many challenges for construction companies. Monitoring silica exposure for workers performing a wide range of tasks using various types of materials and tools in changing work environments requires frequent and repetitive monitoring. TSI real-time instruments offer an affordable tool to meet the challenges of the OSHA standard.

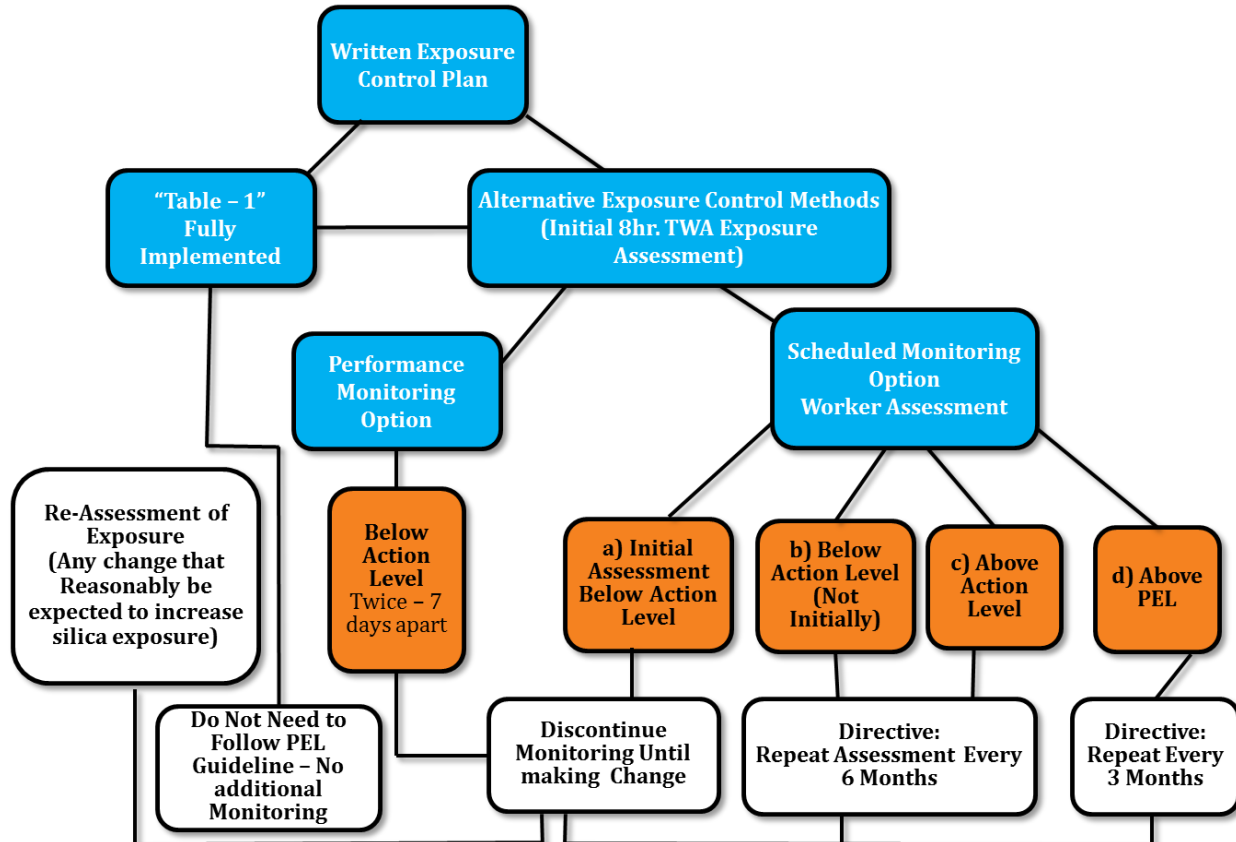
For example: Exposure Assessment—Scheduled Monitoring Option within the Standard)

“Employer must perform initial monitoring to assess the 8-hour TWA exposure for each employee based on personal breathing zone air samples to determine the exposures of employees on each shift, each job classification, in each work area. Where several employees perform the same task on the same shift and work area, the employer may sample a representative fraction of these employees to meet the requirement.”

Following the statement above from the OSHA standard—if a construction company with 30 employees on each of two shifts, who perform 10 different tasks with the same materials, silica exposure on the similar tasks are likely to be very close to each other. In this case, dust monitoring on each of the 10 tasks on each shift for a total of 20 samples, could be used to represent the 60 workers since their exposure to silica can be expected to be similar. If different materials are used or if adjustments and validating various engineering controls are needed, this could require additional sampling. Real-time instruments from TSI are ideally suited for these types of repetitive applications monitoring silica exposure from similar materials.

The previous flow chart [also shown below] outlined the many significant areas of the OSHA silica standard and the pathway of alternative exposure control options. Real-time instruments provide companies with the ability to quickly and affordably address the demands of reaching and maintaining compliance within the standard in most every area.

New Silica Rule—Roadmap of Exposure Control Methods



The table below looks at each significant part of the OSHA standard indicated on the flow chart and acts as a guide to the challenges for silica exposure monitoring in each area and how a real-time monitoring solution from TSI can address these challenges.

Meeting the Challenges of the Silica Standard with TSI Real-Time Silica Dust Monitoring

| OSHA Silica Standard | Challenge for Employers | TSI Real-Time Product/Solution |
|---|---|---|
| Permissible Exposure Limit | Challenge | SidePak™ AM520 Personal Aerosol Monitor/DustTrak™ II Aerosol Monitor |
| <i>The New OSHA standard states "Employer must ensure that no employee is exposed to an airborne concentration of respirable crystalline silica in excess of 50 µg/m³ as an 8-hour TWA (PEL)" The OSHA standard also sets the new action level of 25 µg/m³ as an 8-hour TWA.</i> | <p>Exposure limits are set for respirable dust as measured at the worker breathing zone while performing work tasks.</p> <p>Depending on adherence to Table-1, and the alternative exposure control method an employer chooses to follow, frequent and repetitive silica exposure monitoring may be required.</p> | <p>Real-time monitoring provides immediate readings and alarms for taking immediate corrective actions.</p> <p>Real-time instruments log data and display total dust and time weighted average (TWA) readings along with detailed alarm data for immediate assessment, action and creation of reports and graphs for review.</p> |
| Written Exposure Control Plan | Challenge | Real-Time Monitoring Advantage |
| <i>OSHA standard requires that an employer must develop and implement a written exposure control plan. This plan describes work tasks and work place exposures and what actions are going to be taken that mitigate them. The plan must include all work tasks where exposure to respirable crystalline silica dust is anticipated along with equipment and materials used that are factors in silica exposure.</i> | This is a highly detailed and comprehensive plan with descriptions of specific methods to limit worker exposure to silica. | <p>The development, implementation and execution of the written control plan, will identify the areas personal exposure monitoring and respiratory fit testing that may be needed.</p> <p>Real-time monitoring can help streamline silica exposure monitoring and facilitate expert respirator fit testing to ensure workers are protected.</p> |

| OSHA Silica Standard | Challenge for Employers | TSI Real-Time Product/Solution |
|--|--|--|
| Specified Exposure Control Method "Table-1" of OSHA Rule | Challenge | PortaCount® Respirator Fit Tester |
| <p><i>"Matches specific construction tasks and equipment with dust control methods known to be effective, so employers know exactly what they need to do in order to limit worker exposures to silica."</i></p> <p><i>"Employers who follow Table-1 correctly are not required to measure workers' exposure to silica and are not subject to the PEL."</i></p> | <p>Table-1 of the OSHA rule is an easy-to-follow guide to help take the guesswork out of protecting workers. Table-1 lists specific tasks, tools and engineering controls and pre-determined work conditions and directs the any need for respirators.</p> <p>Employers are charged with fully and completely implementing Table-1 and ensuring engineering controls are working properly and respirators are effective.</p> | <p>Quantitative fit testing for respirators to ensure maximum protection for each worker as required by the OSHA standard.</p> |
| Enclosed Cabs or Booths: Included in Table-1 of the rule | Challenge | Real-Time Monitoring Solution |
| <p><i>Enclosed cabs or booths are specified for certain equipment and activities. Employers must ensure the cabs are clean, maintained and dust controls like door seals and filtration systems are functioning and efficient.</i></p> | <p>Being sure that dust controls are working properly. Frequency of cleaning and inspections are documented in the written exposure control plan. However, periodic personal exposure monitoring of the operator will ensure engineering controls remain effective.</p> | <p>Real-time dust monitoring provides portable and repeatable exposure assessments to ensure that enclosed cabs and booths are protecting workers as designed.</p> |

| OSHA Silica Standard | Challenge for Employers | TSI Real-Time Product/Solution |
|---|--|--|
| Alternative Exposure Control Methods | Challenge | DustTrak II and DustTrak Hand-Held Aerosol Monitors/SidePak AM520 Personal Aerosol Monitor |
| <i>"For tasks not listed in Table-1, or where the engineering controls, work practices and respiratory protection described in Table-1 are not fully and completely implemented."</i> | <p>Specific course of action is much less defined than in Table-1 of the rule.</p> <p>Initial exposure assessments for common materials can prove to be time consuming and costly, especially in large organizations with many workers potentially exposed. Repeated follow-up exposure assessments commonly required.</p> | Real-time dust monitoring provides real-time exposure assessments quickly and at less cost while providing data for reporting and tracking exposure. |
| Initial Exposure Assessment | Challenge | SidePak AM520 Personal Aerosol Monitor/DustTrak II and DustTrak Hand-Held Aerosol Monitors |
| <i>When using an alternative exposure control method i.e.: non-Table-1 tasks, "Employer must assess the exposure of each employee who is or may be reasonably expected to be exposed to respirable crystalline silica at or above the action level of 25 µg/m³ as an 8-hour TWA."</i> | <p>Performing initial and on-going assessments to the Action Level for each employee over an 8-hour work shift can prove to be a significant challenge for employers.</p> <p>The standard allows for similar job classifications to be represented by a smaller sample of employees performing like tasks, with similar exposure to silica. Although this can reduce the number of sample studies required, it does not include dissimilar tasks which will require repetitive monitoring.</p> | Real-time monitoring will help you identify the source of silica exposure and monitor each employee quickly and cost effectively. |

| OSHA Silica Standard | Challenge for Employers | TSI Real-Time Product/Solution |
|--|---|--|
| Alternative Method – Performance Option | Challenge | SidePak AM520 Personal Aerosol Monitor |
| <p><i>“Provides employers flexibility when determining an 8-hour TWA exposure level for each employee. This assessment can be based on a combination of air monitoring data or objective data that can accurately characterize employee exposure to silica.</i></p> <p><i>Exposure assessment must representative the exposure of employees on each shift for each job classification in each work area.”</i></p> | <p>If objective data (material type for example) cannot be applied, employers must conduct a qualitative exposure assessment before work begins.</p> <p>When employee exposure has been properly characterized, exposure must be reassessed if a change is made where higher level of silica exposure can be expected.</p> | <p>Real-time dust monitoring provides exposure assessments for quick characterization of silica exposure by task in addition to capturing detailed data trails that can be reported and graphed.</p> <p>This provides employers more information for characterizing tasks and employee exposures when using the performance exposure assessment option.</p> |
| Alternative Method – Scheduled Monitoring Option | Challenge | SidePak AM520 Personal Aerosol Monitor |
| <p><i>Scheduled monitoring option directs employers as to when and how often exposure monitoring must be performed.</i></p> <p><i>Initial exposure monitoring is required for an 8-hour TWA with the minimum being “[each job function, each job classification, in each work area and on each shift]”.</i></p> <p><i>Employer can apply exposure characterization for employees performing similar tasks on the same shift. As with the performance option, correct characterization of employee exposure is important.</i></p> | <p>Initial exposure assessments are required across employee functions, shifts, jobs and work areas. This can create a challenge for employers with many job classifications. In addition to the initial assessment and characterization based on the employee with the highest exposure, additional exposure monitoring is also required over time. When applying characterization of exposure, keeping reports of the assessments is important.</p> | <p>Real-time dust monitors pull samples from the worker breathing zone. Monitoring in real-time provides data that can be quickly compared to another worker to determine which employees have the highest silica exposure.</p> <p>Data logging and reporting provided by real-time monitoring is beneficial in the process of characterizing employee exposure levels and record keeping.</p> |

| OSHA Silica Standard | Challenge for Employers | TSI Real-Time Product/Solution |
|--|--|---|
| Alternative Method – Scheduled Monitoring; Directive A | Challenge | SidePak AM520 Personal Aerosol Monitor/DustTrak II Aerosol Monitor |
| <i>When the initial silica exposure assessment is below the action level, exposure monitoring can be discontinued for this task if the results of a near-term follow-up study are the same. If a change is made that can reasonably be expected to change the silica exposure level for the employee. Additional monitoring is required.</i> | <p>Must repeat until two consecutive gravimetric samples taken 7 or more days apart prove exposure levels are below the action level.</p> <p>Changes to materials, process, equipment etc. could potentially require a reassessment be done. This judgment could be somewhat subjective and studies could take time consuming and be costly.</p> | Real-time monitoring allows for quick, low-cost reassessments when changes are made so employers can be confident that employee exposure is within limits after changes have been made. |
| Alternative Method – Scheduled Monitoring; Directive B | Challenge | SidePak AM520 Personal Aerosol Monitor/DustTrak II Aerosol Monitor |
| <i>“Where most recent, but not the initial, exposure monitoring results indicates that the employee levels are below the action level, the employer must repeat the monitoring within 6 months.”</i> | When exposure is above the action level, repeating exposure studies in 6 month intervals can be time consuming and costly. | Real-time personal exposure monitoring makes this quick and cost effective. Provides confidence that exposure controls are working prior to final gravimetric sampling. |
| Alternative Method – Scheduled Monitoring; Directive C | Challenge | SidePak AM520 Personal Aerosol Monitor/DustTrak II Aerosol Monitor |
| <i>“Where the most recent exposure studies indicate that employee exposures are at or above the action level but below the PEL, the employer must repeat the monitoring within 6 months.”</i> | When above the action level, repeating exposure studies in 6-month intervals can be time consuming and costly. | Real-time dust monitoring provides high repeatability of exposure assessments quickly and at a low cost. |
| Alternative Method – Scheduled Monitoring; Directive D | Challenge | SidePak AM520 Personal Aerosol Monitor/DustTrak II Aerosol Monitor |
| <i>“When the most recent exposure monitoring indicates the employee exposures are above the PEL, the employer must repeat the monitoring within 3 months.”</i> | Exposure above the PEL level requires repeating exposure studies more frequently, which is time consuming and costly. | Real-time dust monitoring provides high repeatability of exposure assessments. Studies can be done quickly and at low cost. |

| OSHA Silica Standard | Challenge for Employers | TSI Real-Time Product/Solution |
|---|---|--|
| Reassessment of Exposures | Challenge | SidePak AM520 Personal Aerosol Monitor/DustTrak II Aerosol Monitor/Environmental DustTrak Aerosol Monitor |
| <i>"Employer shall reassess exposure whenever a change in the production, process, control equipment, personal, or work practices may reasonably be expected to result in new or additional exposures at or above the action level has occurred."</i> | Changes on the job happen frequently, putting more focus on the need for real-time dust monitoring to ensure low exposure levels are maintained in a changing work environment. | Real-time dust monitoring provides high repeatability of exposure assessments at a low cost. Enables immediate alerts to hazardous conditions so quick corrective actions can be made before doing gravimetric sampling. |

Establishing a Silica Dust Measurement Program

For many companies, the new OSHA silica standard is changing the level of safety responsibilities required within organizations—requiring engineering controls, personal protection equipment, and initial silica monitoring requirements as well as frequent and regular exposure assessments for compliance. As a result, safety managers are taking on an expanded safety role within organizations

Where to Start?

As part of the new OSHA standard, construction employers must develop and implement a written silica exposure control plan and provide it to the designated competent person(s) within the organization for implementation and ongoing execution of the plan.

Written Silica Exposure Control Plan Defined

The exposure control plan is a comprehensive assessment that describes all tasks, functions and materials in the workplace that create exposure to crystalline silica. It describes the task, work methods, silica monitoring methods, engineering controls, equipment and policies the company will implement to reduce employee exposure.

If construction companies are fortunate enough to have a full-time Industrial Hygienist (IH) on staff, they are likely already busy looking into this. They may even have historical exposure monitoring data to review and an existing plan for reviewing jobs, tasks and activities within the organization that are likely close to or above the new PEL.

OSHA has made available a sample exposure control plan that includes examples, descriptions and guidance of what should be included in each section. This information can be found in guides provided at www.OSHA.gov/silica and searching "written exposure control plan."

If a company does not have the required written exposure control plan or a designated employee who meets the OSHA requirement for a competent person, TSI recommends hiring a Certified Industrial Hygiene (CIH) consultant to help develop a comprehensive exposure control plan that meets the OSHA requirement. A CIH has the knowledge and experience to create a plan to evaluate workplace exposures and determine what tasks,

jobs, functions or activities that will require initial and ongoing evaluation for silica exposure.

Competent Person for Meeting the OSHA Standard

The OSHA standard defines a competent person(s) within the organization as one who has the knowledge and ability to identify existing and potential silica exposure hazards. This person(s) must have the authority to take action that will eliminate silica exposure hazards and implement the written exposure control plan on an ongoing basis. This person is also responsible for the ongoing silica exposure assessments for workers in functions across the company and may choose to hire a CIH consultant to perform the ongoing monitoring and reporting.

If a company wishes to use a consultant, the American Industrial Hygiene Association provides lists of independent consultants and consulting firms at www.aiha.org, and searching “exposure assessment.”

Developing a Silica Exposure Assessment Plan

A silica exposure assessment plan takes the written exposure control plan to the execution stage. This is a careful assessment of employees, tasks, tools and materials to determine where silica exposure is not in compliance.

The basic elements of an exposure assessment is to identify tasks and activities performed by workers (contained in the written plan) and evaluate the silica exposure levels for each task. This data is used to determine what exposure controls need to be implemented and to validate that those controls are effective in reducing silica exposure levels. Exposure controls include engineering controls, workplace practices, changes to task or location, etc. Real-time dust monitoring instruments are ideal for performing these assessments because of the potentially large number of studies in the assessment plan along with the wide ranging tasks and repetitive nature associated with these assessments.

As described earlier, each exposure control method of the standard (Table-1 or the Alternative Exposure Control Methods) determines if additional assessments must be done and at what frequency they need to be carried out.

Basic Elements of an Exposure Assessment Plan

If you have been told “go figure out how to comply with the new silica standard,” you will need a plan.

Elements of an Exposure Assessment Plan

- Identify—tasks and activities
- Evaluate worker exposure—measure and monitor
- Implement controls—equipment changes
- Validate improvements—measure and monitor
- Continue to monitor effectiveness

Initial Silica Exposure Assessment

An initial assessment is needed for any task not included on Table-1 of the standard or when Table-1 is not being followed. The initial assessment is a comprehensive set of monitoring studies usually performed on each employee for each job task to determine if silica exposure levels are above the PEL or action level. Depending on the job site, this could also include administrative staff in offices adjacent to work areas.

Silica exposure studies can be performed by either a designated competent person(s) within the organization (as defined in the standard) or a CIH Consultant hired by the company. The results of the assessment will help to determine if controls or changes are needed to reduce silica exposure to an acceptable level.

Sustainable Monitoring in Real-Time

Direct reading instruments from TSI like the SidePak AM520 Personal Aerosol Monitor and DustTrak II Aerosol Monitor are easy-to-use and provide real-time data measurements to move companies down the path from assessment to compliance faster with less cost. Access to real-time data allows for faster response to high exposure situations providing improved protection than with traditional gravimetric analysis.

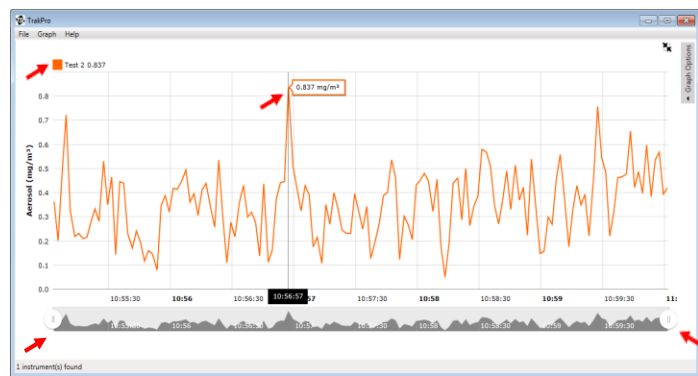


Real-time instruments do this by measuring dust levels in a particular air sample or aerosol. Once calibrated to the known silica concentration level, the instrument is capable of estimating silica exposure levels that are representative of what would be expected from a laboratory analysis of a gravimetric sample. The logged data can be graphed to show trends and review high concentration spikes, to detail exposure levels during alarms and generate detailed reports for later review.



**TSI SidePak AM520
Personal Aerosol Monitor**

TSI TrakPro™ Data Analysis Software



Data logged with real-time instruments help employers get a better understanding of silica exposure in real time to gain insights into the relationship between a worker's activity and silica exposure levels during an entire shift—without having to wait for lab results.

How Real-Time, Direct Reading Instruments Work

Direct reading instruments like the SidePak AM520 Personal Aerosol Monitor are a great tool to help evaluate silica exposure levels. The SidePak AM520 Monitor uses a light-

scattering technology to measure aerosol concentration. An air pump in the instrument draws aerosol into the unit and through an optical chamber. Light from an LED Laser is scattered by this aerosol. The intensity of the scattered light is measured by a photo detector. The instrument displays the aerosol mass concentration based on the intensity of the light scattered by the same amount of a calibration test dust. These are referred to as light-scattering photometers and are very reliable for providing a precise, repeatable measurement.

Because light-scattering photometers cannot differentiate between light scattered by silica and light scattered by other types of dust and aerosol, they need to be calibrated for silica levels. This ensures they provide an accurate representative reading of silica exposure and are not considered a reference measurement by OSHA. For this reason, light-scattering photometers like the SidePak AM520 Monitor cannot be used as a final determination if employee exposures are above the PEL for silica. A gravimetric sample is required for this final determination. However, real-time instruments can be used for exposure measurements leading up to the final gravimetric sample. Real-time instruments collect valuable data that helps make on-going monitoring much easier, faster and less expensive as employers make changes to exposure control methods—ensuring no surprises when a final gravimetric sample is analyzed.

Calibrating Real-Time Instruments for Silica Monitoring

Real-time dust monitoring instruments can be calibrated to precisely read most respirable dust (aerosols) including silica. The instrument will provide a repeatable measurement of an aerosol right from the factory. However, until it is calibrated to align with a gravimetric reference measurement of a specific dust (silica) in a construction environment, its measurement will be based on a different aerosol (much like setting your watch to the correct time zone).

Real-time instruments use a Photometric Calibration Factor (calibration factor) to align measurements to specific dust or aerosol. Because the contents of each aerosol is different, a new calibration factor must be created to properly align the instrument to that aerosol.

Creating a new/custom calibration factor is not difficult once you know what information is needed, where to find it and the formula needed to calculate the calibration factor. If the silica content of the base material remains unchanged, and the process is the same, the calibration factor can be used indefinitely for that specific material.

Calculating a calibration factor to measure for silica is done in three-steps.

1. **Collect the information needed** for use in calculating a calibration factor.
2. **Calculate a calibration factor** to the silica concentrations found in the total dust mass concentration.
3. **Enter the new calibration factor** into the real-time instrument.

Step 1: Collect Information

The information needed is obtained from two sources:

1. Lab analysis of a gravimetric sample of respirable dust.
2. Data from a real-time, direct-reading instrument that will be used to monitor silica exposure.

For this reason, initial exposure assessments are best done with both gravimetric sampling and real-time monitoring done at the same time. Real-time monitoring can be accomplished by:

- a) Using the DustTrak II Aerosol Monitor with a built-in gravimetric sampling filter *or*
- b) Using a SidePak AM520 Personal Aerosol Monitor along with a gravimetric sample pump co-located with both taking measurements from the worker breathing zone using a PM4 Dorr-Oliver Cyclone (see graphic below).



Initial Assessment with 'co-location' method:

Co-located sampling uses both the SidePak AM520 Monitor and a traditional gravimetric sampling pump with both instruments using a PM4 Dorr-Oliver Cyclone within the breathing zone of the worker.

This will provide the information needed to calculate a calibration factor for the **Total Respirable Dust** using the following formula:

$$PCF = \frac{\text{Reference Concentration}}{\text{Data Log Concentration}} \times ECF$$

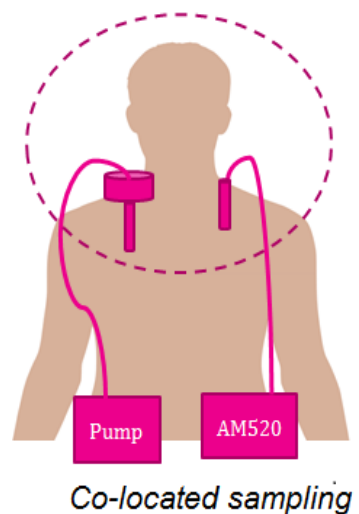
PCF = Photometric Calibration Factor

Reference = Gravimetric Average Concentration

Data Log = AM520 Average Concentration

ECF = Existing Calibration Factor of Real-Time Instrument
(factory default calibration is 1.0)

Initial worker co-located breathing zone assessment with SidePak AM520 Monitor and gravimetric sample pump.



Gravimetric Sample Pump: The gravimetric sample is collected via a sample pump with a collection filter that is sent to an accredited laboratory for analysis. The lab will provide a report of the analysis that contains the following information:

1. **Total mass concentration** of the respirable dust sample
2. **Average. mass concentration** of respirable dust/m³—TWA of 8 hours
3. **Amount of respirable silica** dust within the sample

Real-Time Measurement Reading: This is determined using a direct reading, real-time instrument measuring from the worker breathing zone. For the purpose of calibrating the instrument to a gravimetric sample, the real-time instrument takes its measurement from the breathing zone alongside a gravimetric sample pump and provides the following information:

1. **Photometer measurement** of the average mass concentration.
2. **The existing calibration factor (ECF)** of the real-time direct reading instrument. TSI provides each instrument a standard calibration factor to a known aerosol at the factory as a default. This is often changed, so the actual value of the current calibration factor is found in the configuration menu of the instrument.

-EXAMPLE-

Assume the initial assessment of a sand blasting operation includes a lab analysis report of a gravimetric sample and a co-located real-time monitor, resulting in the following data set (using a PM4 cyclone at 1.7 ml/hr flow rate):

- Average Gravimetric Mass Concentration = **.82 mg/m³**
- Gravimetric Respirable Silica Content = **.086 mg/m³**
- Real-Time Average Mass Concentration = **.58 mg/m³**
- Existing Calibration Factor from Real-Time Instrument = **1.0**
(TSI factory default)

Step 2: Calculate a New Calibration Factor for Respirable Silica Dust

Once the above information has been obtained, a new **calibration factor for respirable silica** can be calculated using the following formula:

Calculating a Photometric Calibration Factor (PCF) to Respirable Silica Dust:

$$\frac{\text{Reference Concentration of Respirable Silica}}{\text{(Average Gravimetric Concentration of Respirable Silica)}} \times \frac{\text{Existing Calibration Factor}}{\text{In Real-Time Instrument}} = \text{PCF}$$

$$\frac{\text{Real-Time Concentration Reading}}{\text{(Average Photometric Concentration)}}$$

Using the example data above along with the formula just described, the calculation for creating a calibration factor for respirable silica is as follows:

EXAMPLE:

$$\frac{.086 \text{ mg/m}^3}{.58 \text{ mg/m}^3} \times 1.0 = .14 \quad \text{New PCF (Calibration Factor) for Respirable Silica}$$

Note: *The formula above does not apply if the silica content is provided by the manufacture of the base material. A different formula is required in that case.*

The result from the above example is a new calibration factor of .14 for the silica content in a particular dust (aerosol). Keep in mind, a calibration factor must be calculated and entered for **each** material containing silica as the silica content will vary depending on the material. It is unlikely that one calibration factor can be used throughout a company's operations.

Step 3: Calibrating the Real-Time Instrument to Silica Concentrations

Enter the calibration factor for respirable silica dust into the real-time instrument (*see the instrument's user manual for details on how this is done*).

Once entered, the instrument will apply the new calibration factor to the aerosol concentration readings. The readings displayed will be representative of the respirable silica concentrations of that dust (aerosol) and will more closely match the expected result of a gravimetric lab analysis from an air sample. TSI instruments hold several custom photometric calibration factors that can be entered and used for specific materials.

Armed with a calibrated real-time instrument from TSI, construction companies can take low cost, real-time studies as frequently as needed across the organization to estimate exposure levels relative to the OSHA standard while working maintain compliance.

TSI offers additional technical application notes on creating custom calibration factors. They can be referenced by visiting <http://www.tsi.com/sidepak-personal-aerosol-monitor-am520/>.

Confirm the Calibration of Real-Time Instruments to a Particular Silica Content

Once the instrument is calibrated to the silica content in a specific aerosol, it is a good idea to confirm that the instruments readings align with the results of a gravimetric sample. The readings will never align exactly, but should be as close as possible. This can be done by simply repeating the co-location of a gravimetric sample pump and the real-time instrument as described earlier in this section. This will allow comparison of calibrated results and facilitate final adjustments to the calibration factor if needed.

Summary

Although not a replacement for gravimetric sampling, real-time monitoring instruments provide significant advantages when determining respirable silica dust exposure. By incorporating real-time dust monitoring for silica, employers can react faster to exposure challenges, validate any actions taken, reduce worker exposure and confidently to maintain compliance to the OSHA standard faster and at less cost.

Real-Time Instrumentation by TSI

For more information on the real-time monitoring instruments and solutions presented in this report, visit www.tsi.com or contact your local TSI representative.

Resources: More Information and Links

There is a growing list of resources available on the topic of silica exposure in the construction industry. Below is a small sampling of the additional information provided for on official U.S. Government websites.

- OSHA's silica rule: www.osha.gov/silica
- The Center for Construction Research and Training: <http://www.silica-safe.org>
- Center for Disease Control and Prevention: <https://www.cdc.gov/niosh/topics/silica/industry.html>
- National Institute for Occupational Safety and Health (NIOSH): www.cdc.gov/niosh
- OSHA – Controlling Silica Exposure in Construction; OSHA 3362-05, 2009: <https://www.osha.gov/Publications/3362silica-exposures.pdf>
- American Industrial Hygiene Association: (www.AIHA.org)
- TSI Application Notes, “SidePak AM520/AM520i Personal Aerosol Monitor Return on Investment” and Photometric Calibration Factor (PCF) Procedures for Respirable Silica: <http://www.tsi.com/sidepak-personal-aerosol-monitor-am520/>
- www.tsi.com/silica



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