Please send comments on the draft SOP to cecilia@cpras.co.za by no later 22 May 2026

Mine Health and Safety Council

MHSC

CENTRE OF EXCELLENCE PROJECTS

CoE 180605: DEVELOP A STANDARD OPERATING PROCEDURE (SOP) THAT WILL ASSIST IN DEVELOPING AND IMPLEMENTING A STANDARDISED MONITORING STRATEGY FOR RESPIRABLE CRYSTALLINE SILICA (RCS) IN THE SOUTH AFRICAN MINING INDUSTRY (SAMI)

1. Purpose of the SOP

The purpose of this SOP is to ensure a standardised and improved quality assurance framework for the RCS monitoring strategy.

2. Scope

This SOP focuses on the monitoring of RCS and was aligned with the following guidelines to develop the associated MCOPs:

a) An occupational health programme encompassing occupational hygiene and medical surveillance of personal exposure to airborne pollutants, herein referred to as the APG (DMR, 2018).
b) A quality assurance programme for occupational hygiene and ventilation engineering measurements, specifically the measurement of the occupational hygiene hazard related to airborne pollutants, herein referred to as the QAG (DMRE, 2024).

This SOP was aligned with section 8 of the QAG, “Aspects to be addressed in the mandatory COP”. In-text references to the subsections of the QAG were made in the format of “QA section nr”.

3. Risk Assessment (QA 7 & 8.1)

A baseline risk assessment should be conducted to assess exposure to RCS as per the APG and QAG. The risk assessment must identify the risk level of RCS exposure in terms of likelihood and impact, and construct a risk matrix. Depending on the controls already in place, the risk may be classed as low, medium or high.

Aspects that relate specifically to RCS personal exposure monitoring should be considered in the risk assessment. Relevant risks that are not identified and controlled would negatively impact the standardisation and quality assurance of RCS personal exposure monitoring.

3.1. Risk to impartiality

Any potential risks to the impartiality of personal RCS exposure monitoring should be identified during the baseline risk assessment. These risks need to be reviewed and monitored continuously. Risks to impartiality may arise from the mine’s activities, its relationships and/or the relationships of its personnel.

Note 1: Impartiality requires objectivity and freedom from bias or conflicts of interest. When impartiality related to RCS exposure monitoring is identified and managed as a risk, it ensures that results and inspections are not influenced by undue pressures from internal or external parties. Impartiality maintains credibility through transparent and unbiased processes. This principle affects all stakeholders across the sample value chain, from the enactment of legislation to the reporting of results to the inspectorate.

Note 2: Relationships that compromise the impartiality of the exposure monitoring team may be based on ownership, governance, management, personnel, shared resources, finances, contracts, marketing (including branding) and the payment of a sales commission or other inducement.

3.2. Risks related to personnel

It is important to identify the risks related to the competency of personnel at all organisational levels, as shown in Figure 1.

The risks associated with capacity and capability in relation to personal RCS exposure monitoring should be identified. Mines should have a sufficient number of competent and trained personnel available to conduct personal exposure monitoring of RCS according to the relevant MCOPs.

3.3. Risk related to personal exposure to RCS

The MCOP sets out measures to ensure that both qualitative and quantitative risk assessment processes are followed, considering all the factors influencing the health of employees as it relates to RCS exposure.

The risk assessment should include the aspects listed below:

- The route of entry of RCS (e.g. inhalation).
- The health effects of RCS on employees.
- Locations within the mining environment where RCS may be present.
- The key workplace operations and activities that pose the greatest potential risk of exposure to RCS.
- The occupations and number of employees who are exposed to RCS.
- The pattern (e.g. intermittent or continuous), duration and frequency of employee exposure to RCS.
- The measured exposure concentrations versus the RCS occupational exposure limit (OEL) and industry milestones.
- The control measures in place.
- The additional control measures required to reduce or maintain exposures to below the OEL.
- Where applicable, planned programmes for implementing control measures,

An ongoing monitoring programme, operating at a fixed frequency, should be implemented to assess the effectiveness of the RCS controls.

The risk assessment should be reviewed annually based on the personal exposure monitoring data from the previous monitoring cycle, ensuring continuous risk management. The reason for the latest risk assessment review should be documented (e.g. as per the annual programme or as a result of control failures).

Historical RCS exposure data must be retained as stipulated in Section 12(3) of the MHSA.

4. Responsible personnel

4.1. Personnel (QA 8.2.1.1.1)

The organisational structure of all personnel involved in monitoring personal exposure to RCS should be defined (see Figure 1). The relationships among the personnel should remain impartial and free from undue influence, meaning no person (or entity) should negatively impact any step in the process of monitoring personal exposure to RCS.

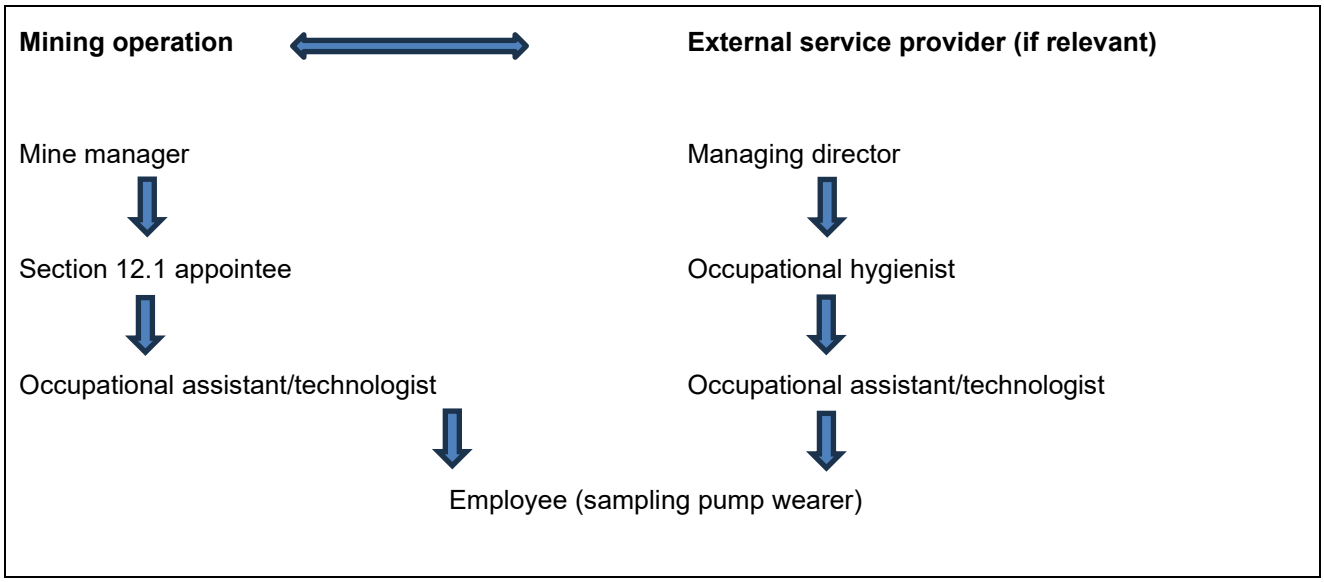

Figure 1: Organisational structure for RCS monitoring

4.2. Minimum qualification requirements (QA 8.2.1.1.2, 8.2.1.1.3 & 8.2.3.6.2/3)

The minimum qualifications of personnel should be aligned with the Mine Health and Safety Act (MHSA) and should be relevant to the monitoring of personal exposure to RCS, as shown in Table 1.

Table 1: Minimum qualification requirements for personnel

Position	Minimum qualification requirements	Recommended training requirements
Section 12.1 appointee	• Certificate in mine environmental control (CMEC) for underground operations	• Certificate in mine environmental control • Continuous knowledge regarding legal requirements • All policies, procedures and MCOPs • Attending workshops and days of learning presented by occupational hygiene associations to keep up to date with occupational hygiene requirements • Original equipment manufacturer (OEM) or authorised company training on the relevant equipment and instrumentation

Position	Minimum qualification requirements	Recommended training requirements
Occupational hygienist	• Intermediate CMEC (surface operations) • AND • Registered as occupational hygienist with The Southern African Institute of Occupational Hygiene (SAIOH) • OR • CMEC for underground operations	• Certificate in mine environmental control • Continuous knowledge regarding legal requirements • All procedures and COPs • Attending workshops and days of learning presented by occupational hygiene bodies to keep up to date with occupational hygiene requirements • OEM or authorised company training on the relevant equipment and instrumentation
Occupational hygiene assistant/technologist	• Registered as an occupational hygiene assistant with SAIOH **OR** • Practical CMEC	• Continuous knowledge regarding sampling techniques • All policies, procedures and MCOPs • Attending workshops and days of learning presented by occupational hygiene associations to keep up to date with occupational hygiene requirements. • Inhouse training regarding occupational hygiene requirements. • Registered as an occupational hygiene technologist with SAIOH • Intermediate certificate in mine environmental control • OEM or authorised company training on the relevant equipment and instrumentation
Employee	• Qualification as per job description	• Awareness training on RCS and silicosis • In-house training on RCS sampling procedure • In-house training on the quality assurance related to RCS sampling during the shift

4.3. Analytical methodologies, laboratory accreditations and regulatory limits (QA 8.2.1.1.3 & 8.2.3.1.1)

Table 2 outlines the sampling and analytical procedures applied for RCS monitoring. The methods documented in the MCOP of the mine should be included in the accreditation schedule of the laboratory.

The facility handling cassette preparation and gravimetric weighing does not need to be accredited (although it is recommended for quality purposes). The gravimetric weighing facility should comply

with the requirements in the QAG Annexure B (DMRE, 2024). Additionally, the following requirements should be met:

a) The microbalance and mass pieces should be calibrated annually by a SANAS-accredited calibration facility, in accordance with national standards.
b) The weighing environment should be maintained at a temperature between 20 and 25 °C and relative humidity between 45 and 55%.
c) The environmental conditions should be measured and recorded using instruments that are calibrated annually by a SANAS-accredited laboratory.
d) Data captured during weighing must be verified and controlled to avoid errors.
e) Personnel should adhere closely to the gravimetric weighing methods documented in the MCOP.
f) Acceptable scores should be obtained in the relevant proficiency testing schemes.

The laboratory conducting RCS analysis must be accredited by the South African National Accreditation System (SANAS) according to SANS 17020 (SANS, 2012) and/or SANS 17025 (SANS, 2018). A valid record of the laboratory's accreditation schedule and expiry date must be kept.

Although the RCS analysis laboratories are inspected by SANAS and/or the Department of Employment and Labour, a representative of the mine should also conduct intermittent visits and inspections to understand the RCS analysis process. The proficiency testing scheme and inter-laboratory testing scores need to be verified and must indicate an acceptable performance.

Table 2 gives the OELs for RCS and Particulates Not Otherwise Classified, Respirable (PNOC).

Table 2: Sampling and analytical methods and OELs

Pollutant	Methodologies	Laboratory	OEL as per the MHSA
RCS	e.g. MDHS 101/2 NIOSH 7602, NIOSH 7500	Laboratory name and SANAS number	0.05 mg/m^3
PNOC	e.g. MDHS 14/4, NIOSH 0600	Mine weighing room OR external laboratory name and SANAS number (if applicable)	3.0 mg/m^3

4.4. Sampling techniques (QA 8.2.1.1.3 & 8.2.3.2 & 8.2.3.7.1)

Sampling equipment for measuring personal exposure to RCS should be prepared, handled, issued, retrieved, transported and stored as described below. These tasks will be conducted on-site at the mine or, where applicable, by the external service provider.

Each RCS exposure sample should be given a unique reference number consistent with the mine's existing numbering system. This number will be used on the sampling sheets and on the analysis request form sent to the laboratory.

Various sampling pumps can be employed for RCS monitoring. The primary brands of sampling pumps available at the mine are Gilian, Casella and AirCheck.

The user manuals for the sampling pumps should be available at the occupational hygiene department and/or with the external service provider. Sampling pumps must comply with ISO 13137 and should maintain the calibrated flow rate for the entire shift.

4.4.1. Sampling equipment maintenance, storage and transportation (QA 8.2.3.2.1, 8.2.3.6.1 and 8.2.3.6.4)

a) The OEM should train authorised personnel on how to handle, maintain, store and transport the sampling pump to protect the instrument and ensure optimal performance according to its intended use.

b) The responsible person or department for the following functions should be documented:

- The management of the sampling pumps (e.g. designated department or personnel), including dispatching faulty units or pumps that are due for their annual service to the OEM.
- Receipt of the calibrated and maintained measuring equipment returned from the OEM or supplier.
- The maintenance and calibration of the sampling pumps.
- Administration and maintenance of instrument records.

c) Only minor maintenance specified by the OEM may be undertaken by authorised personnel.

d) The sampling pump must be calibrated before and after each sampling shift with the individual sampling media to be used for personal sampling attached. The calibrated meter should be used to verify the flow rate.

e) If the sampling pump cannot maintain the required flow rate for the entire shift or if the flow rate cannot be verified, the sampling pump needs to be inspected and serviced by the OEM. Other items in the sampling train should be inspected by authorised personnel.

f) The sampling pump should be wiped clean with a damp cloth before and after use to remove dust from contaminating clean samples. The exact cleaning protocol to use should be confirmed with the OEM.

Warning: The sampling pump should not be submerged in water.

g) The battery of the sampling pump should be sufficient to allow sampling over the entire working shift of the employee, typically 8 to 12 hours (a minimum of 80% of the shift or more if overtime is worked).

h) If a sampling pump is not running when returned after sampling, the issue should be noted on the sampling sheet, including any associated errors or alarms. The relevant employee should be interviewed to determine why the sampling pump stopped running. Depending on the model of pump, data should be downloaded to investigate when and why the sampling pump stopped running. If the sampling time did not cover at least 80% of the employee's shift, the sample should be discarded and recorded as either a "lost shift sample" or "rejected".

i) The sampling pump must be stored in a secure location before and after use, ensuring that it is free from dust contamination or excessive heat exposure.

j) The sampling pump should be transported safely in a dedicated padded backpack or transport box with foam inserts.

k) When a sampling pump is returned from the OEM after being serviced, the following functional checks should be performed:

- Verify that a service report accompanies the sampling pump and review it for any comments or concerns.
- Inspect and verify the sampling pump prior to use.

l) If a flow rate calibrator was sent to a SANAS-accredited laboratory for calibration, the certificate should be reviewed for the following:
- The accreditation status and validity of the calibration laboratory, confirmed via the report and SANAS website.
- Identification of the calibrated instrument (e.g. serial number or company-assigned reference number).
- Validity of the calibration and expiry dates.
- The flow rate ranges were covered as per the mine's requirements.
- If correction factors arise during the calibration and have to be applied going forward, all relevant staff need to be trained on the implementation.

  Note: Refer to SANAS' technical document number TR 25 for additional guidance on reviewing the calibration certificate (*click here*).

m) The verification and service reports, and the calibration certificates of the instruments, should be stored in the equipment records management system (electronic and hard copies).

4.4.2 Sampling pump flow rate verification procedure (QA 8.2.3.2.1a)

The flow rate of the sampling pump must be verified before and as soon as possible after the RCS exposure sampling of an employee.

Note: Although this process is often referred to as pre- and post-calibration, it is not a calibration. This process merely verifies that the flow rate is set correctly.

a) The sampling pump should be switched on in a clean environment, and then run for approximately 10 minutes to warm up and allow the flow rate to stabilise. This step is especially important in cold temperatures, where the flow rate can be affected.

b) The airflow calibrator should be cleaned before use.

c) An airflow calibrator should be used to verify the sampling pump's flow rate. The calibrator itself must be calibrated at least once per year by a SANAS-accredited laboratory, and records of the valid calibration certificates must be maintained.

d) The sampling media consists of the pre-weighed filter membrane and a backing pad or metal mesh in an enclosed cassette. An ISO 7708 (ISO, 1995) compliant cyclone with a grit pot should be attached to the cassette.

e) The grit pot should be secured to the cyclone with a cable tie to leave sufficient space for large dust particles to collect inside.

   Note: Ensure the grit pot is positioned at the correct height to avoid blocking the cyclone outlet. Blockage would result in a false over-exposure to RCS because all the dust would be collected on the filter rather than only respirable dust particles.

f) The flow rate of the sampling pump must be set according to the specified rate for the cyclone.

g) The sampling pump's flow rate should be confirmed with the individual sample media attached. The flow rate should be adjusted to be within ± 5% of the set flow rate.

Note: Do not calibrate using a dedicated sampling media in a closed container. Cyclones and filters introduce their individual uncertainty, and therefore, the flow rate must be verified with the individual sampling media attached (both before and after sampling).

h) A minimum of three flow rate readings must be taken to determine the average flow rate prior to sampling.

i) If using a bubble flow rate meter, the soap solution in the calibrator should be replaced regularly according to the manufacturer's guidelines.

j) On completion of the flow rate verification prior to sampling, the pump should be switched off and disconnected from the calibrator.

k) A sampling pump leak test should be performed by blocking the inlet (i.e. suction side) of the sampling pump while the pump is running.

l) When the sampling media is connected to the pump, a sampling train leak test should be performed by blocking the inlet of the cyclone while the pump is running.

m) If both leak tests show a complete seal without air leaks in the system, the sampling pump will start to stutter and may even stop running. When the blockages are removed, the sampling pump should start running again without interference from the operator and at the required flow rate, with no errors or alarms indicated on the pump. If the pump is still showing errors or not working, it is necessary to troubleshoot the problem. If the problem cannot be resolved, the sampling pump should be replaced and steps a) to l) must be repeated.

n) On completion of the sampling process, steps g) to h) should be repeated to confirm that the post-shift flow rate remains within ± 5% of the required flow rate.

4.4.3. Issuing of a sampling pump and wearing the equipment (QA 8.2.3.2.1.a, 8.2.3.7.1)

The employee to be monitored for RCS exposure will wear the sampling train. The wearer should be:

a) Informed of the sampling schedule and instructed to collect the sampling train at the designated place, such as the lamp room or waiting place.

b) Briefed on the following:

- The reason for the RCS sampling: compliance with legal requirements and employee protection.
- The sampling method.
- The importance of protecting the instrument and refraining from tampering.
- The need to keep the cyclone in the upright position and the inlet unobstructed throughout the shift.
- The requirement for a mid-shift inspection to confirm that the pump is running, the sampling media remains attached and correctly positioned, and the inlet is not obstructed.
- Instructions on sampling pump operation and to be aware of any errors or alarms.
- The obligation to wear the sampling train for the full working shift.
- To return the sampling train without damage to the designated area for removal.
- To record any event, including abnormal events, especially events that could potentially result in high exposures, on the chain of custody form.

4.4.4. Pre- and post-sampling procedure (QA 8.2.3.2.1 a and 8.2.3.8.1.e)

a) On completion of the pre-sampling steps in section 3.4.2, all relevant information should be captured on the sampling sheet (refer to Table 3).

b) The sampling pump should be attached to the employee's belt or chest with a harness. The cassette containing the filter should be clipped to the employee's clothing in the breathing zone (i.e. approximately 30 cm from the nose and mouth).

c) The sampling pump should be switched on once the sampling train is secured and the start time recorded on the sampling sheet.

d) At the end of the shift, the sampling pump is switched off.

e) The stop time is recorded on the sampling sheet.

f) The sampling train needs to be carefully removed from the wearer without subjecting it to mechanical shocks.

g) Cyclones must be kept upright when switched off to avoid the contents of the grit pot falling onto the filter.

h) The grit pot should be removed from the cyclone, and the inside should be inspected. Any observations, such as high dust levels or moisture, should be recorded on the sampling sheet.

i) The grit pot should be cleaned by shaking out the visible dust or gently blowing into the grit pot to remove fine dust. To avoid eye irritation, close your eyes before blowing air into the grit pot.

j) The grit pot should be secured to the cyclone.

k) Without removing the cassette and filter, the cyclone should be inverted and the sampling media placed in the sturdy transport case fitted with foam inserts.

l) The sampling media should be kept upside down (i.e. dust-side of the filter on top) to prevent sample loss during handling.

m) The sampling pumps and sampling media should be carefully transported to the area where the post-sampling flow rate will be verified.

Table 3: Sampling sheet and chain of custody

Sampling sheet		**Respirable crystalline silica**	
Date		Mine activity area	
Employee name		Shift (day/night)	
Company number		Shift duration (hours)	
Employee occupation		Employee signature	
Sampling media			
Filter number		Pump type	
Filter type (MCE, PVC, Silver)		Pump number	
Filter size (25 or 37 mm)		Flow rate calibrator expiry date	

Cyclone type & number		Pump position (belt/chest)	
Pump start time (min)		Pump Stop Time (min)	
Average pre-shift flow rate (L/min)		Average post flow rate (L/min)	
Difference in flow rate (L/min)		Pass/fail ± 5% range	
Total sample time (min)		Volume (m^3)	
Analysis information			
Gravimetric weighing laboratory name		RCS laboratory name	
Dust analysis method		RCS analysis method	
Dust laboratory accredited (Yes/No)		RCS laboratory accredited (Yes/No)	
Dust mass (mg)		RCS concentration (mg/m^3)	
Respirable dust concentration (mg/m^3)		TWA RCS (mg/m^3)	
TWA respirable dust (mg/m^3)		% RCS in sample	
Mid-shift inspection			
Environmental conditions (wind direction, speed, humidity and temperature)			
General comments			

Chain of custody	**Date and time**		**Comments and observations**
	Handout	**Receive**	
Gravimetric weighing room			
Occupational hygienist/assistant			
Employee			
Driver			
RCS laboratory			

4.4.5. Sources of errors (QA 8.2.3.2.1a)

There is a need to be aware of and avoid the following common sources of error:

a) Failure to clean the cyclone before use.
b) Using a sampling pump that does not comply with ISO 13137.
c) Using a cyclone that is not ISO 7708 compliant.
d) Sampling without a grit pot attached to the cyclone.

e) Using area sampling methods to assess personal RCS exposure.
f) Extrapolating short-duration results (also known as "grab" samples) or results for less than 80% of the shift to an 8-hour exposure.
g) Failure to accurately record the sampling time.
h) Failure to present data and related information in a neat, organised format.
i) Failure to verify or adjust the flow rate of the sampling pump to the required rate.
j) Using a "self-calibrating" sampling pump without independent verification with a flow calibrator
k) Failure to maintain the sampling media in the correct position during and after sampling.
l) Improper storage of samples after collection.

4.4.6 Storage and transportation of RCS samples (QA 8.2.3.2 d & e)

Pre-weighed sample filters should be prepared by the relevant laboratory (mine or external service provider) for RCS personal exposure sampling. Each blank filter should be assigned a unique identification number by labelling the petri-dish slide and cassette holder. **Do not write on or mark the filter itself**, as this will cause damage to the filter and negatively affect the weight. Consistent numbering patterns should be followed (e.g. alphabetical letters followed by an alphanumeric number). The laboratory must maintain a sample register to track all batch numbers generated and ensure the traceability of each sample. These records must be maintained for a set duration according to the requirements of the mine (e.g. lifetime or 5 years).

Records of the filter number and sampling sheet information should be captured and stored together.

After the sampling process, the sampling media should be transported by an authorised person to the gravimetric weighing laboratory as soon as possible. The sampling media should be transported in containers that protect the integrity of the sample and avoid sample loss or contamination. Transport boxes must be handled with care and kept upright at all times.

An analysis request form should be completed with instructions for the laboratory. The unique sample number, with the corresponding analysis required, should be noted on the analysis request that accompanies the used samples.

Any abnormalities and/or discrepancies should be reported to the laboratory, such as:

- The sample train was opened, compromising sample integrity.
- Damage to or moisture inside the sample transport boxes or holders.
- Missing sampling media during the shift.
- Sampling pumps that remained running because they could not be switched off.
- Loose dust inside the filter cassette.
- Sampling time was less than the specified time.
- Filters returned unused.

Upon receipt, the laboratory should inspect the RCS samples and document the sample condition. If any discrepancies are detected or the sample has been compromised, the authorised person at the mine should be notified. If necessary, approval must be obtained to continue with the analysis.

Once samples are received by the laboratory, they should be stored in their individually marked petri dish slides in the gravimetric weighing room. The weighing room's environmental conditions need to be closely controlled and monitored. The temperature should be kept between 20 and 25°C, and the relative humidity should be maintained between 45 and 55%. The environmental conditions should be measured and recorded with instruments that are calibrated annually by a SANAS-accredited laboratory.

The RCS filter samples should be acclimatised under the same conditions as the blank filters to ensure the weight of the filter is stable. The duration of acclimatisation depends on the filter type. Post-sampling weighing should only be conducted once the weight is stable.

Note: Mixed-cellulose ester (MCE) and polyvinyl chloride (PVC) filters are typically acclimatised for at least 12 hours. Silver filters can be acclimatised for only a few hours unless the dust is wet, in which case overnight acclimatisation is required.

On completion of the gravimetric weighing, the samples should be sent for RCS analysis by securing the petri dish slides together in groups and placing them in a secure container, whilst keeping the filter upright at all times (dust side on top of the filter). The container must be handled with care until it reaches the RCS laboratory.

Field blanks or unused sample media should be included in the transport container and should be analysed for potential contamination. Field blanks should never contain RCS.

The RCS samples should be retained or disposed of following mine-specific instructions.

4.4.7 Sampling frequencies and duration (QA 8.2.3.3.1, 8.2.3.5.1, 8.2.1.1.4)

The sampling schedule for personal exposure to RCS should be reviewed annually after evaluation of the previous cycle's results. The schedule should follow the MCOP for airborne pollutants. The sampling schedule for RCS should include the following information (APG, 2018):

- The sampling exposure category (e.g. A, B, C or D).
- The HEGs.
- The number of samples to be taken per annum (minimum of 5% of employees within a HEG, with a minimum of five samples (whichever is greater)).
- The frequency of sampling, with the aim of distributing the number of samples equally over the year.

The personal RCS exposure measured for any individual employee within an HEG should be allocated to both the exposure records of that specific employee and all the other employees within that HEG. Sampling for RCS should be randomly assigned to different employees on different days over the monitoring period within the same HEG. All job categories within a HEG need to be randomly sampled as far as reasonably practicable.

As far as reasonably practical, personal RCS sampling should be conducted over the full duration of the shift. Although full shift sampling is recommended, this may be challenging at times. Based on the MHSC Handbook for Occupational Hygiene Monitoring (MHSC, 2007), it is advised that a minimum sampling period of 6 to 8 hours is used. This duration is approximately 80% of an 8-hour shift. Consequently, a minimum of 80% of the shift should be sampled. If the sampling time is less that 80% of the shift duration, the reasons should be recorded and the RCS sample must be discarded. The same employee's RCS exposure should then be monitored at the earliest opportunity.

Note: When the shift duration is 12 hours or longer, 80% of the shift is 10 hours or more.

Planned task observations (PTOs) should be conducted by the supervisors for all personnel involved in the RCS sampling process, e.g. Section 12.1 indicates that an annual PTO is conducted on the occupational hygiene assistant.

Note: An example of a PTO is provided in Appendix A.

4.4.8. RCS sampling equipment (QA 8.2.1.1.3)

Details of the instrumentation used for RCS personal exposure monitoring, including their functionality and characteristics, are provided in this section.

The Section 12.1 appointee should ensure that each person involved in the personal RCS exposure sampling is trained on the instruments used. The training should be conducted by the OEM or a person authorised to conduct such training on behalf of the OEM.

4.4.8.1 Sampling pump

a) Specificity:

The sampling pump should be prepared based on the correct sampling method specifications, such as the required flow rate.

b) Accuracy:

- Before flow rate verification, the sampling pump should be cleaned and charged, and all components should be in a good condition.
- The air sampling pump should be connected to the calibration train following the manufacturer's guidelines. All components should be attached correctly, with no loose or leaking connections.
- If sampling heads or tunes contain 'O' rings for sealing, it must be ensured that they are in place and undamaged.
- The manufacturers' guidance for the sampling pump should be consulted. Some older sampling pumps require a warm-up period where they need to be run before calibration.
- The flow rate on the sampling pump should be adjusted according to the user manual until the appropriate flow rate is displayed.
- After the RCS sampling is completed, the sampling pump's flow rate should be confirmed. It should not have deviated by more than 5% from the pre-sample value.
- Samples should be transported according to the manufacturer's instructions.
- A regular schedule of service and maintenance should be established and strictly adhered to for the accurate performance of the sampling pump over time.
- A calibration schedule should also be established and adhered to.

c) Precision and interferences:

- Flow rate range: Older sampling pumps may have a narrow flow rate range. Newer sampling pumps are capable of providing low and high flow rates.
- Flow compensation: Users should confirm with the manufacturer that the sampling pump has automatic electronic flow control and is not influenced by filter loading, pinched tubing or obstruction at the cyclone inlet. The automatic electronic flow control should be verified at regular intervals.
- Pulsating flow: It should be confirmed that the sampling pumps have pulsation dampers to reduce inconsistent pulsation of airflow.
- Worker's movements: The mobility of the wearer should not be impaired by using the correct length of tubing, the right pouch, positioning of the pump (belt or harness) and sampling train assembly.

d) Detection limits do not apply to sampling pumps; however, the lowest flow rate at which the pump runs continuously without stuttering should be identified.

e) The sources of uncertainty are:

- Faulty construction, calibration and maintenance of the sampling pump.

- Misuse, rough handling or neglect that damages the internal components of the sampling pump.
- Incorrect flow rate used for the cyclone.
- Sampling times that are not representative of employee exposure to RCS.
- Storage and transport conditions that do not protect the sampling pump.

4.4.8.2. Flow rate calibrator

a) Specificity: The flow rate calibrator must be fit for use with the sampling pump.
b) Accuracy and precision monitoring:
   - Setting and verifying the sampling pump flow rate using a flow rate calibrator is critical for personal RCS exposure sampling. Incorrect verification will lead to regulatory compliance issues.
   - Calibration: Only SANAS-accredited facilities should be used to calibrate the flow rate meter with traceability to recognised international standards.
   - Established guidelines and standards should be followed when verifying or setting the flow rate with the calibrator meter.
c) Detection limits: The operational ranges for the flow rate calibrator should be confirmed with the manufacturer, typically a flow rate of 0 to 10 L/min and a temperature range of -25°C and +50°C.
d) The sources of uncertainty include:
   - Faulty construction, calibration and maintenance of the sampling pump.
   - Misuse, rough handling or neglect that damages the internal components of the sampling pump.
   - Incorrect flow rate used for the cyclone.
   - Sampling times that are not representative of employee exposure to RCS.
   - Storage and transport conditions that do not protect the sampling pump.
   - Uncertainty factors declared on calibration certificates are incorrectly applied.

4.4.8.3. Potential RCS sampling errors and their control (QA 8.2.3.9 a-c)

Sampling errors occur when the actual measured value differs from the "true" predetermined value. Measurements of RCS personal exposure will improve our understanding of an employee's workplace environmental conditions. Although absolute accuracy is not achievable, the aim is to minimise or reduce errors as far as possible. Errors may arise during the measurement process due to different factors. Examples of potential errors and their potential control measures are listed below:

a) Potential errors:
   - Faulty construction, calibration and maintenance of the sampling pump
   - Misuse, rough handling or neglect that damages the internal components of the sampling pump
   - Incorrect flow rate used for the cyclone.
   - Sampling times that are not representative of employee exposure to RCS.
   - Storage and transport conditions that do not protect the sampling pump.
   - Data capture errors when taking flow rate readings or recording the data.
   - Measurements can be affected by external environmental conditions such as temperature, pressure, humidity and air flow.
   - Individual bias or carelessness during observations.
   - Incorrect setting of the flow rate
   - Carelessness when making observations.
   - The person being sampled tampers with the sampling equipment.

- Calculations such as flow rate readings or gravimetric weighing were conducted incorrectly.

b) Potential controls:
   - Verify flow rates using a different person on selected sampling pumps before sampling.
   - Carefully follow and regularly improve the sampling procedure.
   - Use the highest precision instruments available (it should be possible to test various measuring instruments for better accuracy).
   - Collect measurements under controlled environmental conditions.
   - As part of the quality control, verify formulas for accuracy.
   - Ensure comprehensive training and intermediate PTOs for employees who are responsible for personal RCS exposure sampling.
   - Thoroughly induct and brief employees who wear the RCS sampling train to ensure they understand the importance of compliance.

ANNEXURE C: Planned task observation for RCS sampling

PLANNED TASK OBSERVATION – personal RCS exposure monitoring	
Date	
Observer conducting PTO	
Position of observer	
Name of person observed	
Position of the person observed	
Procedure followed (as per the information provided by the person observed):	
Check the validity of the calibration certificate of the calibrator	
Plan accordingly: use the correct sampling media for RCS exposure sampling.	
Assemble the sampling train and connect to the calibration source	
Complete the sampling sheet and chain of custody	
Perform pre-sampling checks on the sampling pump	
Plan accordingly: RCS sampling for at least 80% of the shift	
Perform pre-sampling checks on the cyclones:	
Tight-fitting grit pot (not covering the outlet)	
Cracks and cuts	
O-Rings (should be in place and not damaged)	
Perform the pre-sampling calibration:	
Run the sampling pump for 10 minutes to warm up	
Connect the sampling pump and sample media to the flow rate calibrator	
Verify the flow rate of the sampling pump and record results in the sampling sheet	
Always use the sampling media that is going to be used for that sample	
Reassemble the sampling train	
Ensure cable ties are fitted to each connection point.	
Seal connections between the cyclone and cassette with insulation tape	
Perform a leak test on the sampling train	
Take the sampling train to the field	
Brief the wearer on the purpose of sampling	
Instruct the wearer not to interfere with the equipment	

Instruct the wearer not to remove the sampling pump themselves (wear for the entire shift)	
Instruct the wearer to record any events that could influence measurements	
Clip the sampling media to the person's clothing (in the breathing zone – 30 cm radius from the nose area), with the filter facing down.	
If using a cyclone, the cyclone opening should face to the front and not be obstructed	
Place the sampling pump on the wearer's belt/inside pocket/inside leather pouch, and start the sampling pump	
Perform mid-shift check on the person and the sampling train	
Collect sample train from person at the end of the shift	
Sample to be retrieved by a competent, trained person	
Switch the sampling pump off and record the time	
Carefully remove the sampling equipment, without subjecting it to any mechanical shocks	
The cyclone must remain upright when the sampling pump is switched off to prevent the grit pot content collecting on the sampling media	
Empty the cyclone grit pot before transportation	
For respirable samples, if the cyclone grit pot is absent on retrieval of the sample, the sample needs to be discarded	
Invert cyclone for transportation	
Record any abnormalities observed - ask the wearer about activities that could have contributed to excessive levels	
Connect the sampling train to the calibration source	
Perform post-sampling flow check and record in the field sheet (flow rate is not adjusted)	
Check that the difference between the pre- and post- calibration is not more than 5%	
Disassemble the sampling train and cap filter cassette	
Used samples should be capped with a red filter cap on the inlet side to ensure they are not used again	
Never use cyclones, cassettes, tubing, or other equipment without cleaning them	
Place the sampling pump on charge for at least 8 hours	
Pack the filter cassette in the sponge holder in the carry case	

The sample must be kept upright (inlet side facing upwards)	
Prepare the laboratory analysis request sheet	
Arrange with the courier company for the collection of samples	
Close carry case with cable tie	
Cleaning of sampling equipment	
Clean cyclones, filter connectors and u-tubes in an ultrasonic bath filled with lukewarm water for at least 10 minutes	
Wipe all other instruments with a damp cloth	
Observations by observer **Name and signature of observer** **Name and signature of person observed**	