Respirable dust and the 225-69 & 225-69-37 Cyclones

Presented by:

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Development of air sampling with cyclones

- The first cyclone developed and used in the UK was the Higgins and Dewell (HD) and it was designed to meet the BMRC curve with a D50 of 5 micron and a sharp cut off and used at 1.9L/min.
- In the late 1960's and early 1970's the HD cyclone was investigated to develop applications in the UK coal industry – the result was the SIMPEDS cyclone.
- Cyclones are used for sampling the respirable dust fraction in the breathing zone for exposures to occupational or workplace exposure limits.
- For a real look at the history a good read is Aerosol Sampling by James H Vincent.

Standardisation of respirable sampling definitions

- During the 1960's and 1970's there were many different cut points from different bodies that required differing designs and different flow rates.
- This stayed in place until 1989 when Sidney (Sid) Soderholm became one of the prime movers in amalgamating these into what we know today as the ISO-CEN definition of inhalable, thoracic and respirable fractions with cut points (D50) at 100, 10 and 4 micron.
- This was adopted by CEN in 1993, then by ISO in 1995 and ACGIH during 1994/95.

Standardisation of respirable sampling definitions

- This lead to ‘EN481:1993 Workplace atmospheres: Size fraction definitions for measurement of airborne particles’ and ‘ISO 7708:1995 Air quality- Particle size fraction definitions for health-related sampling’ being issued during this period.
- At this time the recommended cyclone flow rate was 1.9 L/min and it was suggested that ‘the performance of samplers with one of the original conventions could also be expected to comply with the new convention’.

Reports and considerations relating to respirable sampling

- The biggest issue is particle size distribution, and also particle shape and mass.
- The D50 is a mid-point reference on the definition curve but different materials may have a much higher distribution of particles from 1-4 micron or from 4-12 micron and may well oversample or undersample. There is no universal ideal sampler for all materials.
- Over time there has been different and conflicting data from various sources depending on test materials and conditions.

Reports and considerations relating to respirable sampling

- In 2001 a report by Peter Gorner et al ‘a Study of 15 Respirable Aerosol Samplers Used in Occupational Hygiene’ showed that results of HD style cyclones from different manufacturers, including SKC, were very similar in performance and cut point.
- Also in 2001 the HSL produced a report entitled “Investigation of the Effects of Extensive Use on the Penetration of Cyclones” which indicated that the 225-69 had a higher D50 nearer to 5 micron.

Reports and considerations relating to respirable sampling

- One of the problems is that we do not know the origin of the cyclones that are tested, their date of manufacture or their condition.
- Another consideration is the accuracy requirements. MDHS 14/4 states: “Samplers meeting the requirements of EN13205 will have accuracy better than or equal to 30%”. However Gorner states the accuracy performance criteria (APC) of 80% or more.

The SKC Plastic HD style cyclone 225-69 and 225-69-37

- In 1989 SKC launched the first moulded plastic version of the HD cyclone which was used at a flow rate of 1.9L/min with the standard internal dimensions of the original metal HD cyclone.
- No independent testing was performed on this cyclone. It had the same internal dimensions as the original HD cyclone and so the expectation was that it would perform exactly as the original.

The SKC Plastic HD style cyclone 225-69 and 225-69-37

- At the end of 1995 new moulding tools were made to replace the original and worn aluminium tools.
- Cyclones manufactured from parts moulded from these new mould tools were first sold in 1996.
- We now know that there were unintentional dimensional changes to the new stainless steel mould tools that resulted in changes to the internal dimensions of the cyclone parts and that these changes were missed by SKC.

The SKC Plastic HD style cyclone 225-69 and 225-69-37

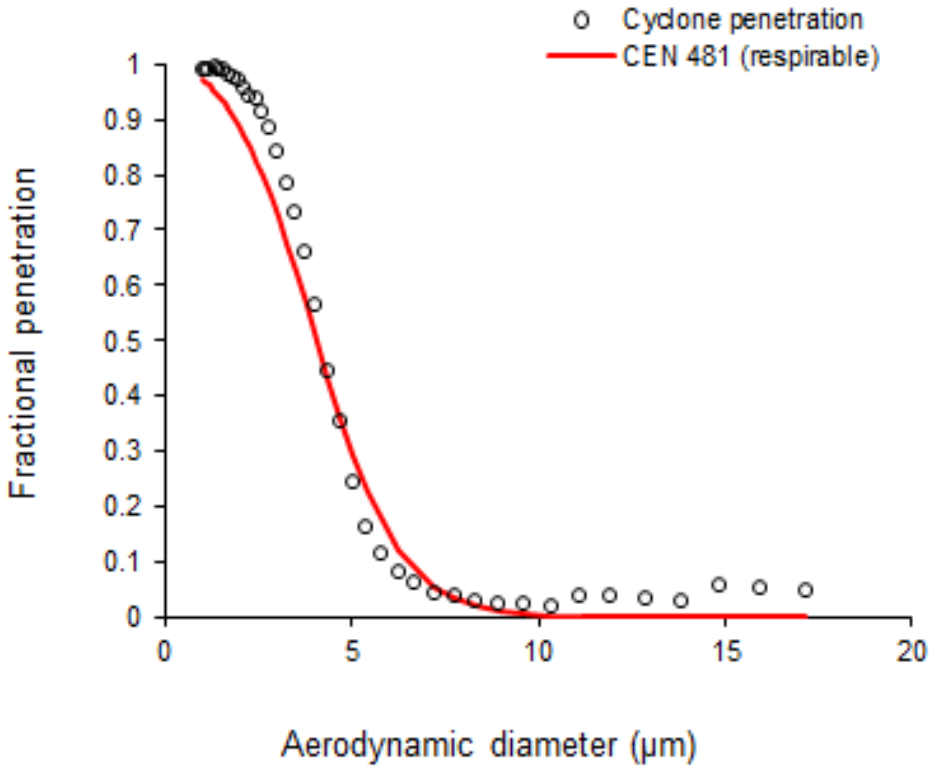
- Around this time with the pending changes to come, it was advised that the cyclones with flow rates at 1.9 L/min should now run at 2.2 L/min to meet the lowering of the cut point from 5 to 4 micron. As far as we are aware no tests were performed by any manufacturer of this type of device.
- It was brought to our attention, after a paper was presented at 'The Australian Mine Ventilation Conference' in Brisbane in August 2017, that the SKC plastic Higgins-Dewell style cyclone oversampled.
- To verify the degree of any oversampling, we had the SKC plastic HD style cyclone assessed against BS EN 481 by the UK's Health & Safety Executive at their laboratory in Buxton at the current flow rate of 2.2 L/min.

The SKC Plastic HD style cyclone 225-69 and 225-69-37

- The HSL results confirmed that at this flow rate the SKC plastic cyclone oversampled with a D50 of over 5 micron, on average by 30%. It is not possible to be precise in predicting the exact degree of over sampling as it will entirely depend on the particle size distribution of the material.
- Further testing at flow rates between 2.2 L/min and 3.0 L/min showed that at 3.0 L/min the fit to the performance curve was extremely close.

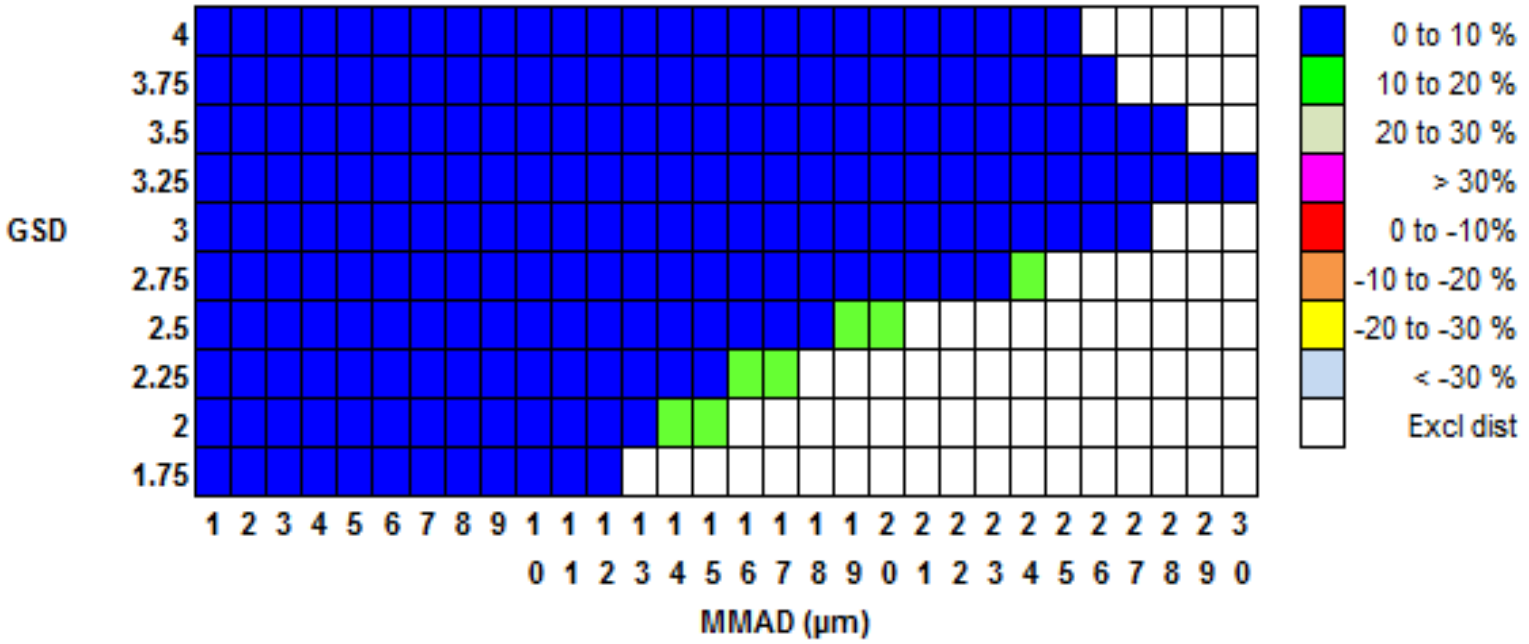
The SKC Plastic HD style cyclone 225-69 and 225-69-37

Curve Fit at 3 L/min



The SKC Plastic HD style cyclone 225-69 and 225-69-37

Bias Map at 3 L/min



The SKC Plastic HD style cyclone 225-69 and 225-69-37

- It did perform reasonably well at flow rates lower than this BUT this was by far the best fit.
- At this higher flow rate there will be a 36% increase in accumulated volume.
- The size of the cassette used has no impact on any oversampling and so the same applies to the 25mm and 37mm versions.

SKC Recommendations for continued use of our Plastic HD Style cyclone and reconciling historical results

- We recommend that our cyclone is now used at 3.0L/min because at this flow rate the performance of the cyclone against the BS EN 481 respirable sampling convention is very good and the resulting increased sample volume will give a lower limit of detection and better sensitivity.
- If customers wish to compare sample results at 3.0 L/min to those previously taken at 2.2 L/min, we suggest that 5 to 6 samples are taken at 2.2 L/min followed by 5 to 6 samples at 3 L/min. This can be done over a few days, but any changes in the workplace must be taken into consideration.
- The HSL in the UK recommended a minimum of 3 comparative samples but that 5 or 6 would be considered statistically significant.

SKC Recommendations for continued use of our Plastic HD Style cyclone and reconciling historical results

- These results can then be used to calculate a correction or correlation factor, and this factor can then be applied to past results.
- It is important to remember that as the SKC Plastic HD style cyclone has been over sampling, the historic results from sampling performed at 2.2L/min would in fact have been lower than actually recorded at the time.
- Guidelines in the UK document ‘G409 Exposure Measurement’ in the control approach section suggest that any results below 30% of the exposure level can be considered as a sound basis for good quality control.

SKC Recommendations for continued use of our Plastic HD Style cyclone and reconciling historical results

- In ‘EN 689 Testing Compliance with Exposure’ it states that 3 samples are acceptable if ALL results are less than 10% of the exposure limit and that the results from 5 samples must be less than 20% of the exposure limit.
- Users should be mindful of recommendations from associations and other organisations who may implement/recommend their own protocol and procedures. The above are only guidelines from SKC.

Impact of increased flow rate on pump run times

- Many customers are already using pumps that comfortably sample for full shifts at 2.2L/min.
- We were confident that our ATEX pumps would be capable of the flow rate increase but to be certain several tests were performed to prove that they could do the same at the enhanced flow rate of 3.0L/min.

Filter	Average Filter Back Pressure at 3 l/min (inches of water)	Pump	Run Time (hours)
225-1930 0.8µm 25mm MCE	16.3	210-3311 AirChek 3000	9 ½
		224-52MTX Sidekick	12 ½
		224-PCMTX8 Universal	13
225-5-25 5µm 25mm PVC	5.6	210-3311 AirChek 3000	13 ½
		224-52MTX Sidekick	19
		224-PCMTX8 Universal	20
225-58F 1.6µm 25mm GFA	5.9	210-3311 AirChek 3000	13
		224-52MTX Sidekick	18
		224-PCMTX8 Universal	19

Good practices

- This situation has highlighted that many customers do not ‘cycle’ their batteries as effectively as they should. For maximum pump performance and battery longevity we strongly recommend that all users cycle their pumps and batteries on a regular basis whether in constant use or not.
- NiMH battery packs usually have a cycle life of 400 to 500 charge / discharge cycles. This will depend on the conditions of charging and use and the general treatment of the batteries over their operating life.
- Regular maintenance of pumps and samplers is essential, particularly inlet filters and O-rings.
- “To achieve the desired particle separation, the internal parts of a cyclone must be clean. Deposits of particulate matter adhering to the sides of the cyclone can alter the size-selection characteristics of the particulate penetrating the cyclone and collected on the filter”.

Implications in Australia

- AS 2985-2009 standard includes a table on ‘Designated Flow Rates for Size-Selective Samplers’ (p. 8, Table 2) which shows the BCIRA cyclone and SIMPEDS cyclone at 2.2 L/min and the aluminium cyclone at 2.5 L/min.
- AS 2985-2009 states: “The respirable fraction shall be collected by using a size-selective sampler conforming to the sampling efficiency curve, see Clause 4.7”.

Implications in Australia

- ‘Evaluation of gravimetric sampler bias, effect on measured concentration, and proposal for the use of harmonised performance based dust sampler for exposure assessment’, B. Belle. *International Journal of Mining Science and Technology*, July 2018.
- “AS2985 made amendments to the definition of the respirable dust aligned with the ISO (1995) definition and cyclones were recommended to be operated at 2.2 L/min flow rate. Currently, further investigations have indicated that almost all of the sampling in some mining regions is carried out using a specific manufacturer, ‘plastic type HD’ cyclone without any reference knowledge of its size-selective performance”.

Implications in Australia

- It also states that test evaluation reports about conformity of the currently available SKC cyclone or Casella cyclone that are used in Australia are not readily available
- The report acknowledges that “the manufacturing challenges of samplers, design variations, inlet geometry variations of samplers, sampler material type, and some discrepancies in evaluation methodology” are known variables
- The report concluded that the cyclone samplers overestimate respirable dust levels and should be discontinued for use ‘in their current design’.
- The HSL test results show that at 2.2 L/min this is a valid statement however at 3.0 L/min the performance is very good.

Customer options moving forward

- Evaluate the correction factor as discussed above to apply to historical results, and for future sampling use the cyclone at 3.0 L/min without the need to apply a correction factor.
- Continue to sample at 2.2 L/min and apply the calculated correction factor.
- Use the SKC IOM Multi-Dust Sampler with foam at a flow rate of 2 L/min and get both inhalable and respirable results at the same time.
- Use an SKC Parallel Particle Impactor (PPI) at a flow rate of 2, 4, or 8 L/min for the respirable fraction.

And finally

Any concerns or questions should be addressed to us at:

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