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Technical Report: *Evaluation of SCC and GK Type Personal Cyclones*

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Summary

The information contained in this report details the design parameters and test results relating to a new variant of the Sharp Cut Cyclone (SCC) specifically configured for personal sampling of PM 1 and larger particulates at a flow rate of 3.5 Lpm and less. Further information is provided on a minor and major variant of the KTL (GK 2.05) cyclone for PM 2.5 sampling.

Introduction

SCC (Sharp Cut Cyclone) and GK, are the designations for a series of tangential, round-entry cyclone geometries. This report details an experimental evaluation of the aerosol size-selective performance of cyclones constructed by BGI Inc for:

1. An SCC intended for personal use having a designator of SCC 1.062.

The dimensions of the cyclone designed for testing were calculated using a model recently refined by Dr. L.C. Kenny of the HSL while performing contract studies for BGI Inc. (HSL Report IR/L/EXM/99/03-Restricted). This model was derived from previous work on novel cyclones by HSL (Kenny and Gussman).

This particular cyclone has a shrouded inlet, intended to reduce directionality effects due to breezes in the workplace. It was tested at several flow rates detailed in Table 1. The complete set of design dimensions are shown in Table 2.
Because the shroud makes it difficult to attach an air flow calibrator to the cyclone inlet, a "calibration chamber" was fabricated for this purpose. In use it is presed over the shrouded inlet and held in place by the friction of a pair of "o" rings.

2. The KTL (GK 2.05) cyclone was developed for the Finnish Institute of Public Health (KTL) and was intended to be used in a rucksack (backpack), with the inlet tube protruding through a grommet. This resulted in a design with an inlet tube excessively long for lapel use. The unit has been redesigned with a more suitable ½ length inlet which requried confirmatory testing.

A new variant of the KTL was also designed with the shrouded inlet. Although not intended for production, the results are also presented.

EXPERIMENTAL METHODS

The experimental methods used to test the cyclones were similar to those described in detail by Maynard and Kenny (1994). Their technique involves the use of either the TSI APS 3310 or 3320, measuring the penetration, through the test device, of polydispersed solid glass microspheres. The latest refinement of this technique is detailed by Kenny *et al* (2000).
The SCC 1.062 cyclone was tested at a numerous flow rates. The significant ones related to D_{50} cut points of 1, 2.5 and 4μM are presented in Table 1. All tests were performed in the horizontal position with the inlet pointing at a right angle to the chamber flow.

The KTL variants were also tested at numerous flow rates. However, only the significant flow rates of 4 Lpm (short tube inlet) and 3.5 Lpm (shrouded inlet) are presented in Table 1.

RESULTS

Figure 2 summarizes the individual penetration curves measured for the SCC 1.062. A PM 1 cut at 3.5 Lpm is confirmed. D_{50} = 1.01 μM, Sharpness = 1.21. PM 2.5 was obtained at 1.5 Lpm, D_{50} = 2.48 μM, Sharpness = 1.20. The closest to the respirable of 4 μM was obtained at 1 Lpm, with a cut of 4.2 μM. The exact flow rate was determined by shifting the results curve and back calculating the flow rate using the equation presented in Figure 3, utilizing all data gathered at a range of flow rates.
The KTL penetration curves are shown in Figure 4.

DISCUSSION

The cyclone designs, herein reported, were tested in the HSE Laboratory. The work was carried out as part of a study of various size selective devices.
During the course of this and previous investigations, the concept of measuring the sharpness of the size selector penetration curve was adopted. This concept was first suggested by Peters *et al* (1996). This method of defining slope is analogous to the Geometric Standard Deviation (GSD) and is calculated from the penetration curve as: Sharpness = $(D_{16}/D_{84})^{0.5}$. The sharpness of cut for all tests is included in Table 1.
The SCC 1.062 was originally designed for lapel use as a research tool to permit assessment of IAQ PM 1 exposures. This has been demonstrated at a flow rate of 3.5 Lpm. The cyclone will also sample for PM 2.5 at a flow rate of 1.5 Lpm, which is low for a gravimetric sample unless high concentrations are to be expected. There is also a demonstratable 4 micrometer cut at 1.05 Lpm but the sharpness of the curve is

steeper than the international respirable curve. The unit would also have application as the size selective inlet for a light scattering photometer.

The shortened inlet version of the KTL cyclone is confirmed at 2.44 μM, agreeing with the previously discovered 4.4 μM for the long tube version.

The shrouded inlet KTL produced a 2.5 μM cut point at 3.5 Lpm with a slope similar to the straight tube version.

CONCLUSIONS

- The SCC cyclone model has been further validated and a new Personal sampler will become available for use known as the "Triplex" SCC 1.062.
- The KTL cyclone performance has been further confirmed with a minor modification to the inlet tube. The performance of a shrouded inlet version of the KTL cyclone has also been confirmed.
- Although the shrouded inlet cyclones are in reasonable agreement with their respective models, they achieve their performance at a lower flow rate. Therefore, a direct, shrouded, modification to the models will await further emperical data.

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Table 1 Cyclone Tests Nov. 10-13, 1999 HSE Sheffield.
LK/RG

Test No.	Family	Dc	Q-Lpm	D50	Sharpness	APS	Remarks
t166	GK	2.05	4	2.44	1.32	3310	KTL, 1/2 inlet
t169	GK	2.05	3.5	2.55	1.32	3310	KTL Shrouded inlet
t170	GK	2.05	3.5	2.49	1.31	3310	KTL Shrouded inlet/Cal. Chamber
t162	SCC	1.062	1.8	2.13	1.2	3310	
t164	SCC	1.062	1.2	3.28	1.19	3310	
t171	SCC	1.062	1.5	2.48	1.2	3310	
t175	SCC	1.062	1.6	2.46	1.18	3310	
t172	SCC	1.062	1	4.2	1.23	3310	
t172e	SCC	1.062	1.05	4	1.22		extrapolated t172
t176	SCC	1.062	1.1	3.76	1.19	3310	
t180	SCC	1.062	3	1.14	1.24	3310	
t181	SCC	1.062	4	0.86	1.22	3310	
t182	SCC	1.062	3.5	1.01	1.21	3310	

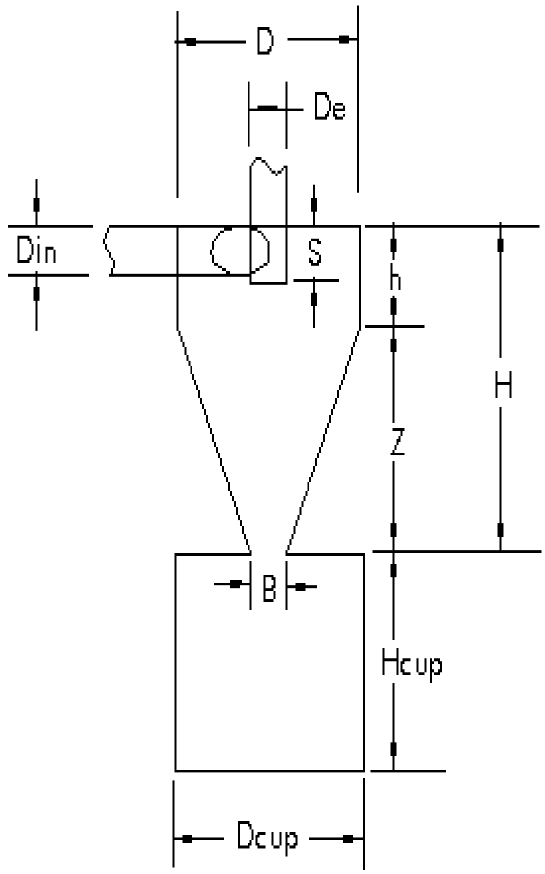

Figure 1 Cyclone Design Dimensions   SCC 1.062

D = 1.062 cm.

Din = 0.255

De = 0.287

B = 0.266

H = 1.657

H = 0.457

Z = 1.2

S = 0.372

Hcup = 0.924

Dcup = 0.674

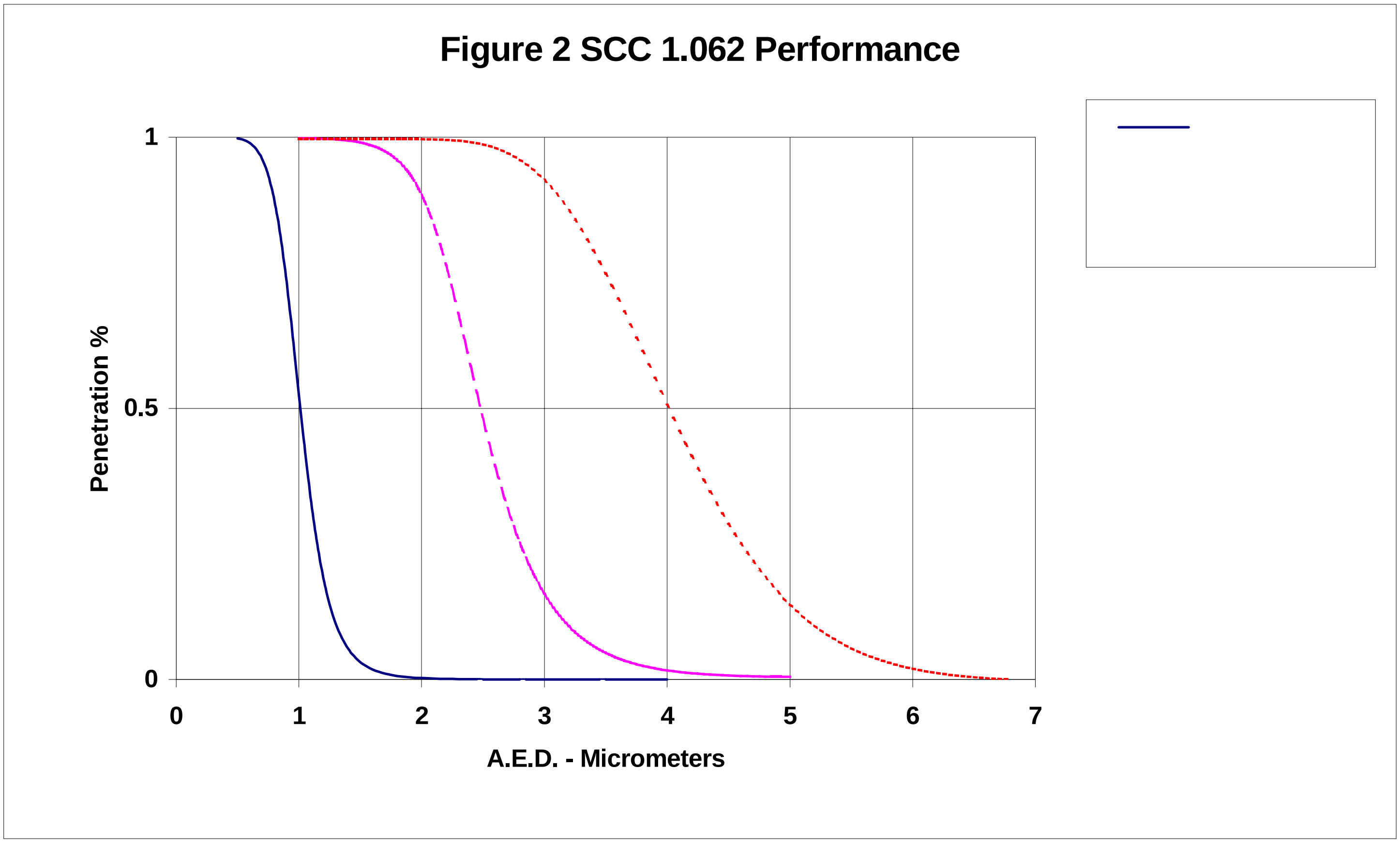
Figure 2 SCC 1.062 Performance
Penetration %
1
0.5
0
0
1
2
3
4
5
6
7
A.E.D. - Micrometers

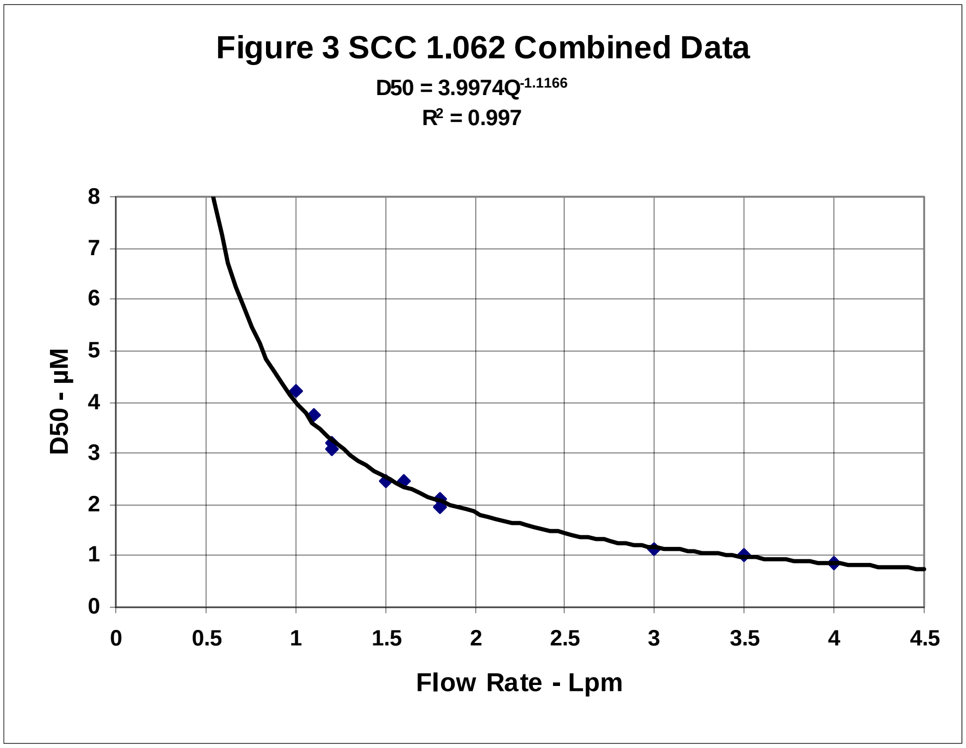
Figure 3 SCC 1.062 Combined Data
D50 = 3.9974Q-1.1166
R2 = 0.997
D50 - µM
8
7
6
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Flow Rate - Lpm

Figure 4 Comparison of KTL (GK 2.05) Cyclones