TECHNICAL REPORT

Title:

EFFICIENCY TEST OF HIGH VELOCITY ELECTROSTATIC PRECIPITATOR CELL

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ABSTRACT :

CTA International ASA has developed a new high velocity cell for their modular designed electrostatic precipitator. Efficiency tests of the cell have been carried out in a filter rig designed for product development and filter efficiency testing. The test rig is located in the HVAC laboratory at the Department of Mechanical Engineering, HiST. The fractional efficiency was calculated according to EUROVENT 4/9.

In total 14 efficiency tests have been carried out. Half of the tests have been carried out with particles from diesel exhaust as contamination source, the other half were carried out with atomized DOS as test aerosols. The air velocity through the net area of the EP-cell has been varied from 4 – 11 m/s. In addition the Electrostatic Precipitator voltage have been varied. The voltage parameters have been included in appendix A. This report will be restricted with appendix A available, and non-restricted with appendix A removed.

KEYWORDS :

Dust cleaning system, efficiency testing, Electrostatic precipitator

1 INTRODUCTION

CTA International has developed a new high velocity cell for their modular designed electrostatic precipitator. On inquiry, HiST Department of Mechanical Engineering carried out fractional efficiency tests on the cell. The purpose of the testing is to determine the fractional efficiency as a function of electrostatic precipitator voltage and air-flow through the cell.

2 TEST RIG AND MEASURING PRINCIPLE

The cell has been tested in a filter rig designed for product development and filter efficiency testing. The test rig is located in the HVAC laboratory at the Department of Mechanical Engineering. Figure 1 shows a sketch of the rig and the instrumentation.

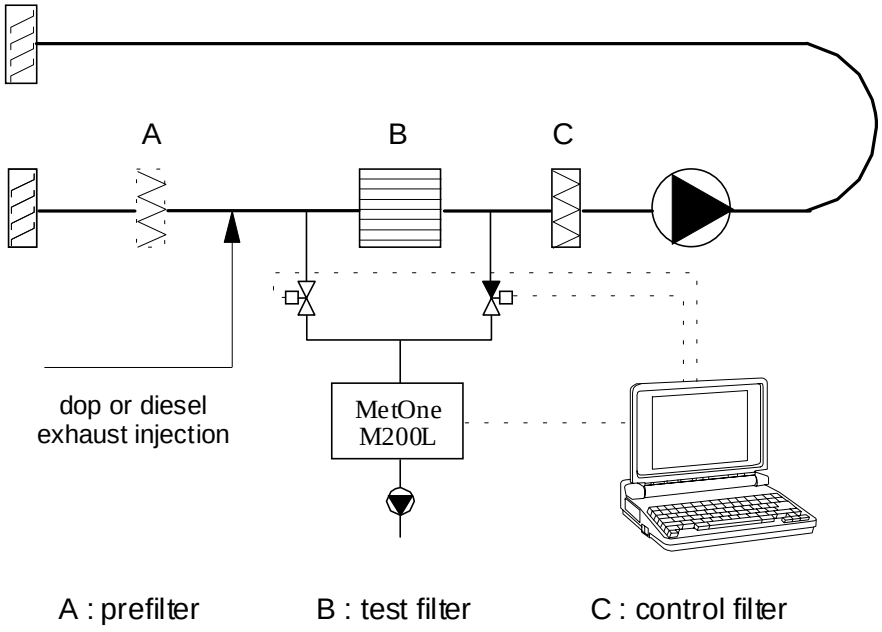


Fig. 1. Filter test rig

The filter test rig for fractional efficiency testing is built of standard ventilation plant modules. It consists of a speed-controlled fan, two measuring sections for upstream and downstream counting of particles, one section for the test-filter, one filter-section for removing outdoor particles and one filter-section for arrestance dust weighing and protection of fan and ductwork. The rig has also a duct section for measuring air velocity, humidity and temperature.

Aerosol particles are generated by a Laskin nozzle aerosol generator, or by injecting exhaust from a diesel engine. Also atmospheric air with natural particle content can be used. When synthetic aerosols or diesel exhaust are injected, particles are added in constant amount and distribution upstream of the filter. Particles that are not captured by the filter are removed from the circuit by means of the control filter. Synthetic dust is generated by converting a liquid, DOS (Dioctyl Sebacete), to aerosols. Using DOS or diesel exhaust gives us good repeatability of particle size and distribution. If atmospheric air is used, the quantity and composition of particles may vary considerably.

The number of particles upstream and downstream the test-filter is counted by using the optical particle counter Met One 200L. The device has a coincidence error less than 5% at 100000 particles/litre. Counts are distributed into six ranges (0.3 - 0.5µm, 0.5 - 1.0 µm, 1.0 - 2.0 µm, 2.0 - 5.0 µm, 5.0 - 10 µm and >10 µm). Particle counting is done successively upstream and downstream of the filter for one-minute periods. The counting cycle is repeated six times per test. Between each count, the particle counter is flushed out for one minute.

The fractional efficiency is calculated according to EUROVENT 4/9.The basic expression of the fractional efficiency for a given particle size range is the ratio of the number of particles retained by the filter to the number of particles fed upstream of the filter. The fractional efficiency (E_1) for one repetition is calculated by Equation (1)

$$E_1 = (1 - (2 * n_2/(N_1 + N_3))) * 100\ [\%] \qquad (1)$$

N_1 : downstream count at time 1
n_2 : upstream count at time 2
N_3 : downstream count at time 3

The final efficiency presented is equal to the average of $E_1..E_6$.

3 TEST CONDITIONS AND RESULTS

In total 14 efficiency tests have been carried out during the test period with the high velocity EP-cell from CTA International. Half of these tests have been carried out with particles from diesel exhaust as the contamination source, the other half were carried out with atomized DOS as the test aerosol. The air velocity through the net area of the EP-cell has been varied from 4 – 11 m/s. In addition the Electrostatic Precipitator (EP) voltage have been varied. On CTA's request, the voltage parameters have been included in appendix A. This report will be restricted with appendix A available, and non-restricted with appendix A removed.

Particle-concentration upstream of the test-filter section has been adjusted by controlling the amount of DOS or diesel exhaust into the test-rig. Figure 2 shows typical concentrations used during the tests. Neither atomized DOS nor diesel exhaust contain a significant number of particles above 5 µm. Therefore no efficiency calculations were carried out for particles above 5 µm.

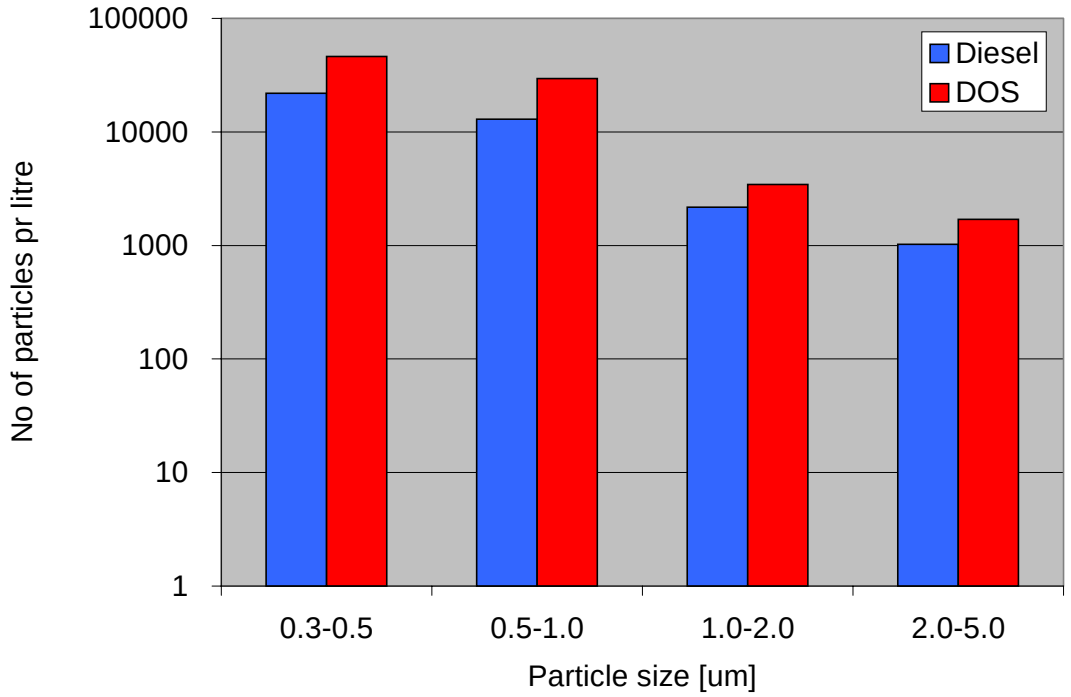
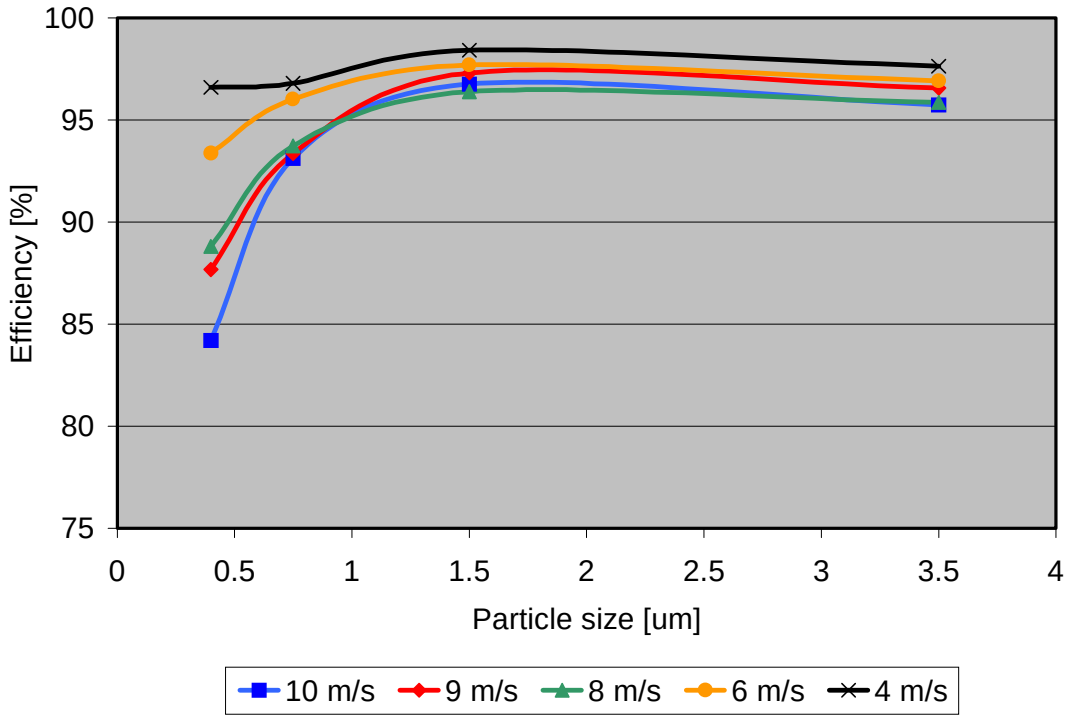


Figure 2. Particle concentration upstream of the test-filter section during test execution.

The results from the efficiency tests are presented below on 4 separate datasheets named fractional efficiency test A to D. Trials with DOS generally show a lower efficiency than corresponding trials with DOS. This is most significant for particles less than 1 µm. The reason for this is most likely the difference in electrical conductivity between the two types of particles (amorphous carbon and dioctyl sebacete). However, one should be aware that carbon which has a very high conductivity, can more easily be re-entrained to the airflow due to particle discharge on the collector surface. The re-entrainment approach becomes distinctive when the dust layer is growing thick.

FRACTIONAL EFFICIENCY TEST A
High velocity EP-cell, CTA International asa

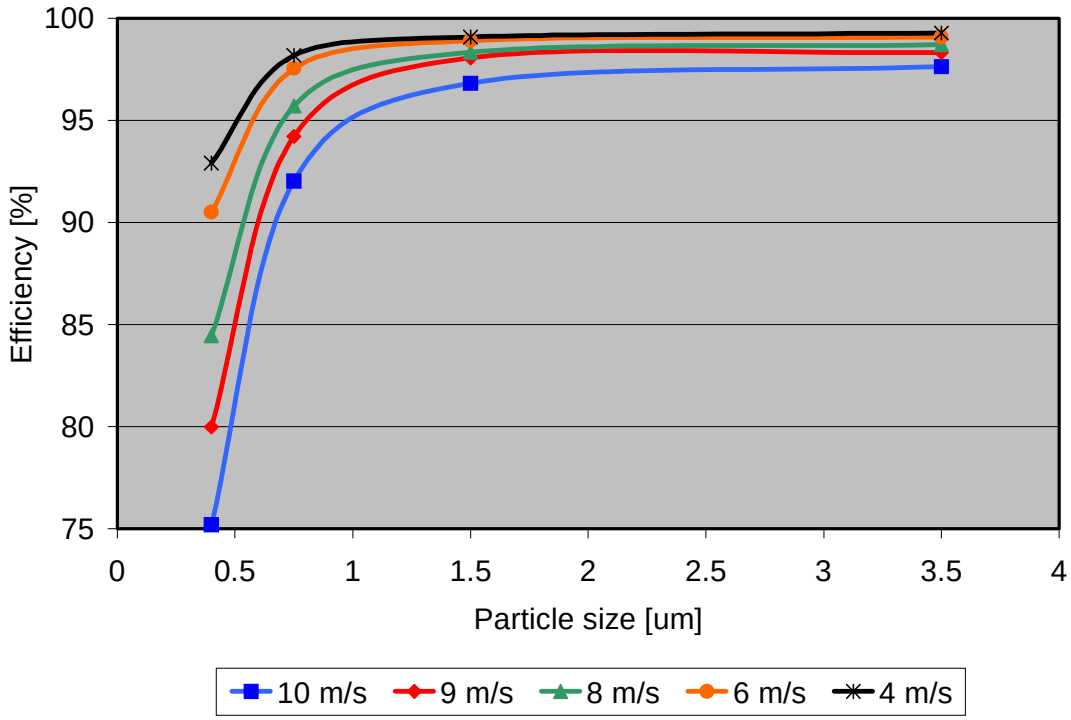
Dust generation : diesel exhaust
EP voltage : see appendix A



	Particle size			
Velocity	0.3-0.5 µm	0.5-1.0 µm	1.0-2.0 µm	2.0-5.0 µm
4 m/s	96.61 %	96.80 %	98.42 %	97.63 %
6 m/s	93.39 %	96.03 %	97.70 %	96.91 %
8 m/s	88.80 %	93.73 %	96.38 %	95.86 %
9 m/s	87.67 %	93.35 %	97.31 %	96.57 %
10 m/s	84.20 %	93.13 %	96.77 %	95.75 %

FRACTIONAL EFFICIENCY TEST B
High velocity EP-cell, CTA International asa

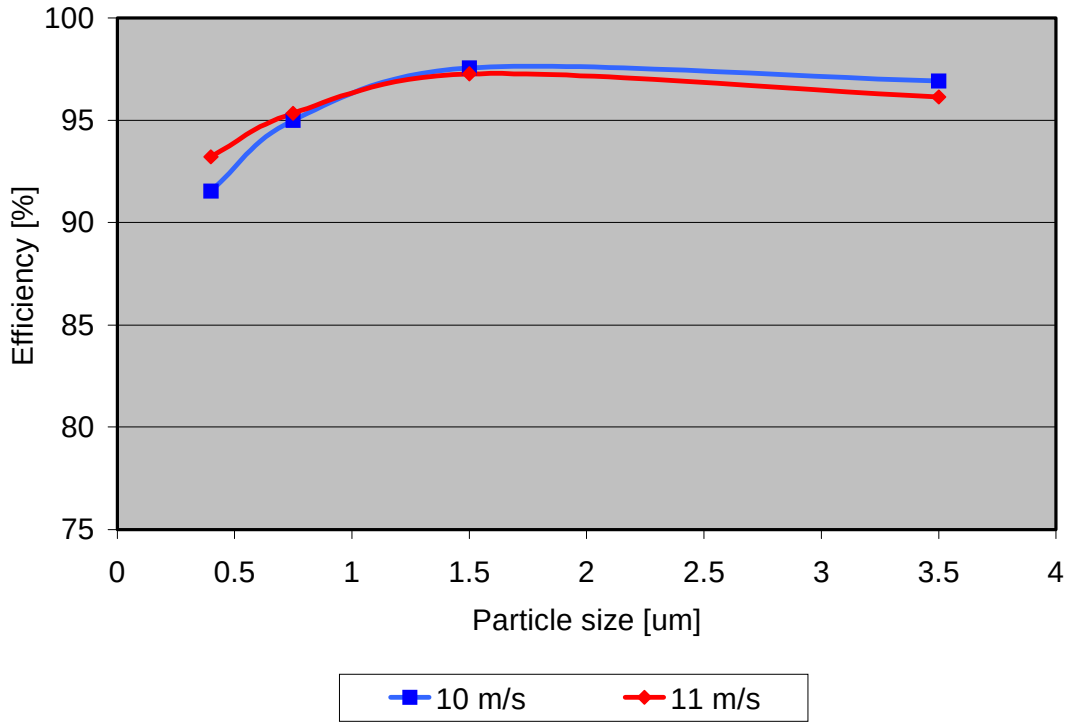
Dust generation : DOS
EP voltage : see appendix A



	Particle size			
Velocity	0.3-0.5 µm	0.5-1.0 µm	1.0-2.0 µm	2.0-5.0 µm
4 m/s	92.91 %	98.19 %	99.07 %	99.27 %
6 m/s	90.50 %	97.53 %	98.90 %	99.09 %
8 m/s	84.45 %	95.70 %	98.35 %	98.71 %
9 m/s	79.99 %	94.22 %	98.06 %	98.33 %
10 m/s	75.20 %	92.03 %	96.81 %	97.63 %

FRACTIONAL EFFICIENCY TEST C
High velocity EP-cell, CTA International asa

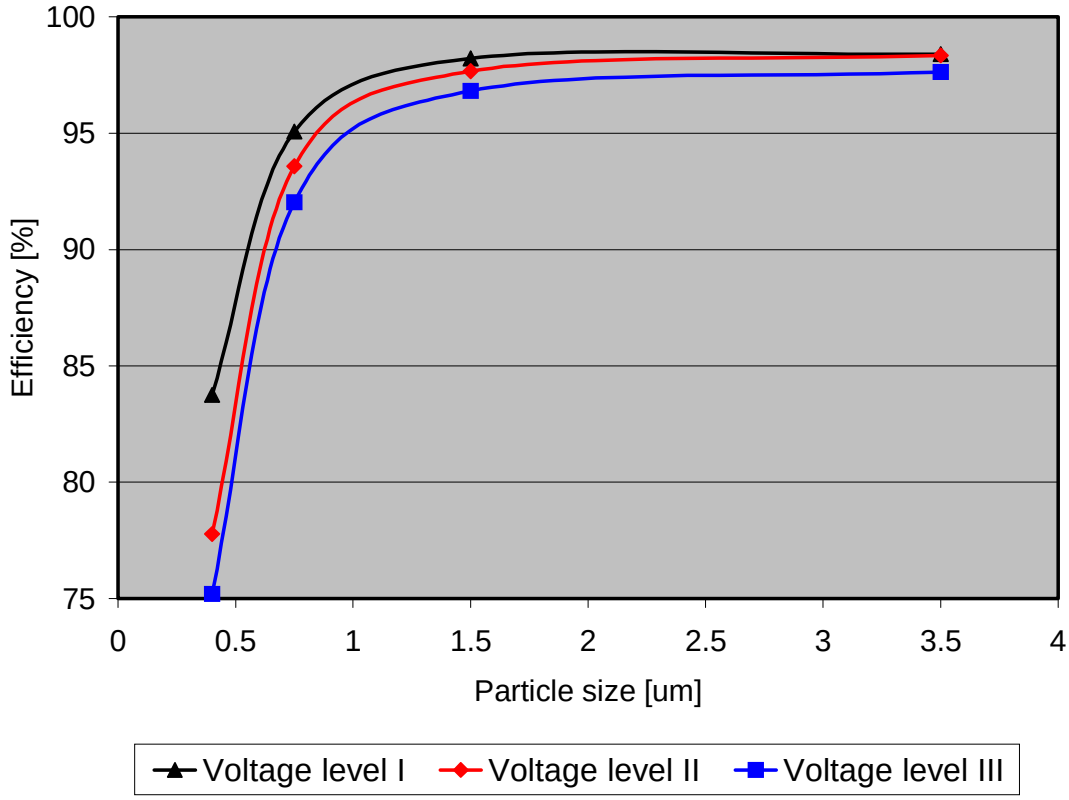
Dust generation : diesel exhaust
EP voltage : see appendix A



	Particle size			
Velocity	0.3-0.5 µm	0.5-1.0 µm	1.0-2.0 µm	2.0-5.0 µm
10 m/s	91.55 %	94.99 %	97.57 %	96.92 %
11 m/s	93.22 %	95.34 %	97.28 %	96.14 %

FRACTIONAL EFFICIENCY TEST D
High velocity EP-cell, CTA International asa

Dust generation : DOS
EP-voltage : see appendix A



	Particle size [µm]			
Voltage level	0.3-0.5 µm	0.5-1.0 µm	1.0-2.0 µm	2.0-5.0 µm
I	75.20 %	92.03 %	96.81 %	97.63 %
II	77.79 %	93.59 %	97.66 %	98.34 %
III	83.75 %	95.08 %	98.21 %	98.40 %