CONFIDENTIEL

MEASUREMENT OF THE EFFECTIVENESS OF THE AIR PURIFIER

TEQOYA TEQAIR 450

ON AN AEROSOL PRODUCED BY COMBUSTION

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Contacts :

Frantz GOURIOU

David PRETERRE

Confidentiality : Yes

Frédéric DIONNET

Directeur Général

CERTAM

Centre d'Etude et de Recherche Technologique en Aérothermique et Moteur

1 rue Joseph Fourier – Technopôle du Madrillet – F – 76800 Saint Etienne du Rouvray

Tél. 33 (0) 2 35 64 37 00 – www.certam-rouen.com

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1 CONTEXT AND EXPERIMENTAL SET UP

CERTAM was solicited by the company TEQOYA to evaluate the effectiveness of an air purifier on particles suspended in the air. The purifier in question consists of a ramp of ionizers whose expected effect is the reduction of particulate concentrations by electrostatic precipitation. It bears the TeqAir 450 reference.

TEQOYA TEQAIR 450

To meet this demand, CERTAM proposed to build an evaluation based on a combustion aerosol produced by a cigarette. This type of seeding has the advantage of being:

- Well mastered and sufficiently reproducible
- Representative in terms of size of the particles present in the air (pollutants related to the automobile, industrial emissions, domestic environments)
- Easy to implement

We have tried to reproduce reasonable concentrations, considering the exposure of people with target values to about 80,000 particles per cm^3, which corresponds to about 10 times the average background level. Such values are commonly achieved in the passenger compartment of road vehicles, especially in urban areas but can also be achieved in business or residential premises (cooking, smoking, presence of combustion sources ...).

This level of concentration is achieved by the complete burning of a cigarette in the test room used.

For information, we can give the following landmarks:

- Very clean air (in medium altitude mountain, far from any anthropogenic source): <1000 p / cm^3
- "normal" air: inside or outside: about 3,000 to 6,000 p / cm^3
- Polluted air:> 10.000 p / cm^3
- Urban air close to the roads: 10.000 to 100.000 p / cm^3
- Road tunnel: 50.000 to 500.000 p / cm^3

Of course, these values are only "guideline" values from our experience. They may not be representative of certain exceptional circumstances.

Measuring equipment:

The particles were characterized using Dekati / ELPI granulometers. This granulometer makes it possible to have access to the particle size distribution of the aerosol products as well as to its particle concentration. It also has a fast response time to follow unsteady phenomena.

Experimental configuration:

The measurements were made in an experimental room with a volume of 75 m^3 with a floor area of 30.16 m^2 and a ceiling height of 2.5 m.

Particle removal was performed at 1.5 m above ground.

The apparatus to be tested was placed approximately in the center of the room.

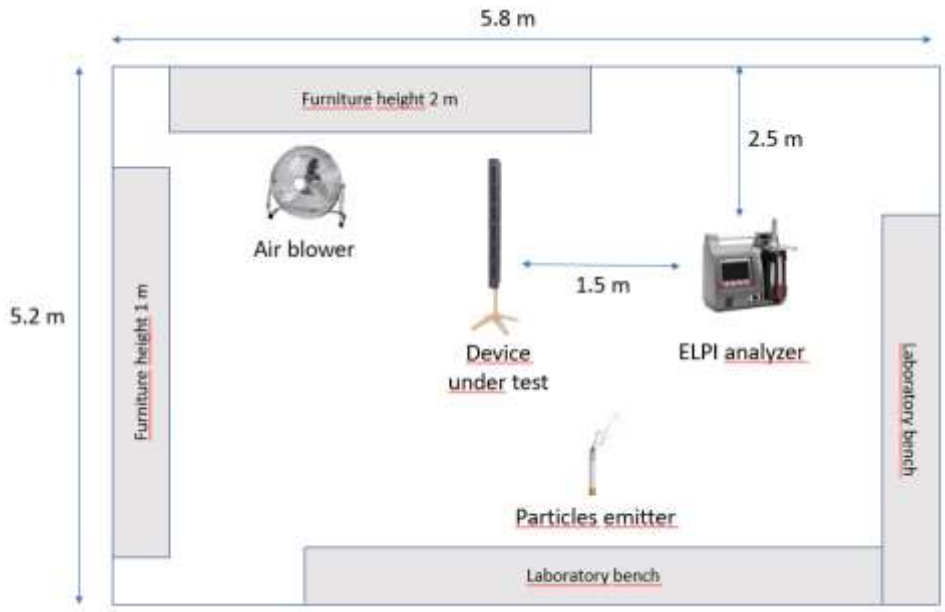


FIG. 1 – EXPERIMENTAL SET UP

It should be noted that for this study, we did not work in a clean room but in a room where background concentrations are in the range of 1,000 to 3,000 p / cm^3. The tests carried out show:

- On the one hand, the good reproducibility of the measurements (on several tests of the same configuration);
- On the other hand, the good consistency between the measurement and its exponential regression (in $y(t) = y_\infty + y_0 e^{-kt}$) with a relative difference of less than 1%. (This decreasing exponential behavior is the expected theoretical behavior of such a test configuration.)

2 MEASURING THE EFFICIENCY OF THE DEVICE UNDER TEST ON THE PARTICLES

In order to better assess the particle abatement efficiency Three separate measurements were performed:

- 2 reference measurements, one out of service device
- 1 measurement with the device in operation

The two reference measurements made it possible to confirm the reproducibility of the experimental set up.

In the following figure (Fig. 2), we provide the adimensioned measures from the starting point of the decay, for a more direct comparison of the results. The unit of the abscissa is the time (expressed in hours) starting from the maximum concentration reached in the test chamber.

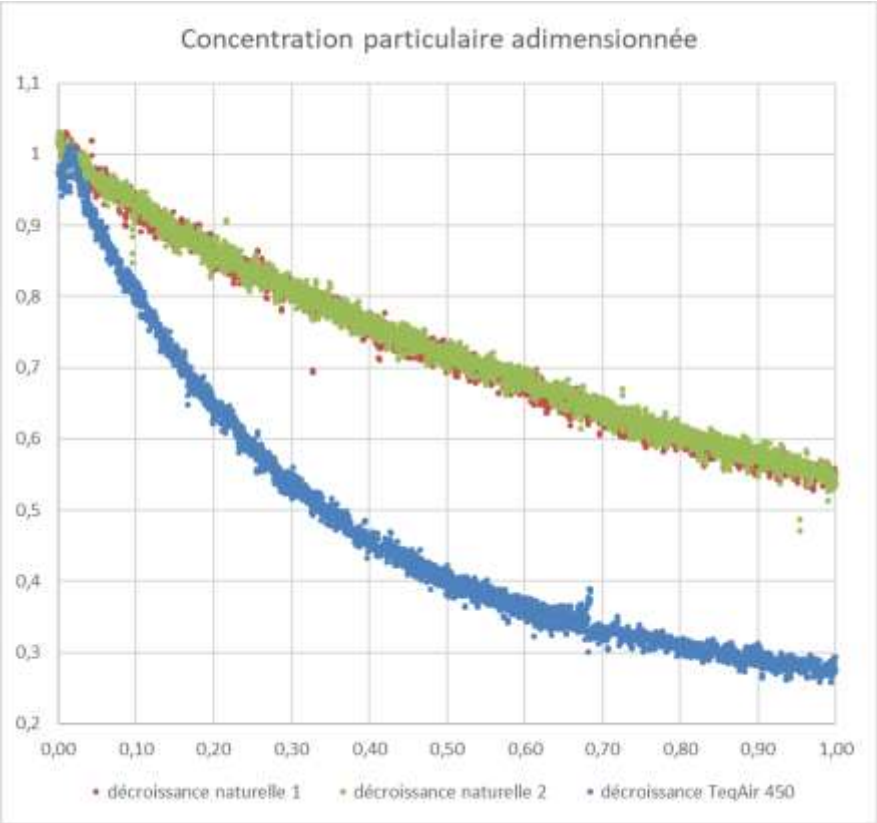


FIG. 2 - TIME TRACKING OF DIMENSIONLESS CONCENTRATIONS

It is clear that the influence of the device is very significant. Particles concentration is divided by 3 less than one hour after peak concentration (whereas it is reduced by less than 50% without the device). In 40 minutes, the concentration is half what it is without the device.

Exponential regression ($Ct=C+C0e-kt$) of these curves provided the following coefficients of abseema (with a correlation coefficient close to 0.99):

	Natural decay 1 (device is off)	**Natural decay 2**	**Decay with device in operation**
k (/hour)	1.15	1.07	3.16

TABLEAU 1 – DECAY COEFFICIENTS K (EXPONENTIAL REGRESSION), DEVICE IN OPERATION AND OUT OF OPERATION

2.1 CADR ESTIMATE

The Clean Air Delivery Rate (CADR) is the purified air rate delivered. It is calculated by comparing the natural abatement (without purification device) and the abatement with device in

operation. The abatement rate is the exponential coefficient of the exponential reduction of the particle number decay curve. Its unit is m^3/h.

$$CADR = V \times (k_e - k_n)$$

where V is the air volume of the test device, k_n the exponential decay coefficient of the particle concentration without purification device, and k_e the coefficient with device under test. The coefficient k is obtained by exponential regression of the particle reduction curve (after reaching the peak of concentration):

$$C(t) = C_\infty + C_0 e^{-kt}$$

where $C(t)$ is the concentration of particles at time t, C_∞ is the particulate background (concentration when t tends to infinity) and $C_\infty + C_0$ is the concentration at the beginning of the measurement range.

The formula for calculating conventional k using all the measuring points is as follows:

$$k = \frac{\sum_1^n t_i \times \ln(C_{t_i}) - \frac{\sum_1^n t_i \times \sum_1^n \ln(C_{t_i})}{n}}{\sum_1^n {t_i}^2 - \frac{(\sum_1^n t_i)^2}{n}}$$

where C_{t_i} is the particle concentration at the measurement instant t_i for each measuring point i, from 1 to n.

If V is expressed in m^3 and t in hours, then the CADR unit of measurement is m^3/h.

An estimate of the CADR was made by approaching the test protocol used in current standards in the United States and China:

- Air mixing in the test room, to ensure the homogenization of the particle concentration, measured at a point in the local
- Measurement performed for 20 minutes, after stabilization and homogenization of the concentration

By applying these conditions, the TeqAir 450 CADR is evaluated at 154 m^3/h.

2.2 INFLUENCE OF PARTICLE SIZE ON EFFECTIVENESS

A complementary research has been to evaluate the link between system efficiency and particle size. The ELPI granulometer provides 12 size classes between 7 nm and 10 µm. An example of the particle size distribution of the aerosol produced during seeding is given in the following figure. Almost all the particles have a size of between 0.02 µm and 1 µm.

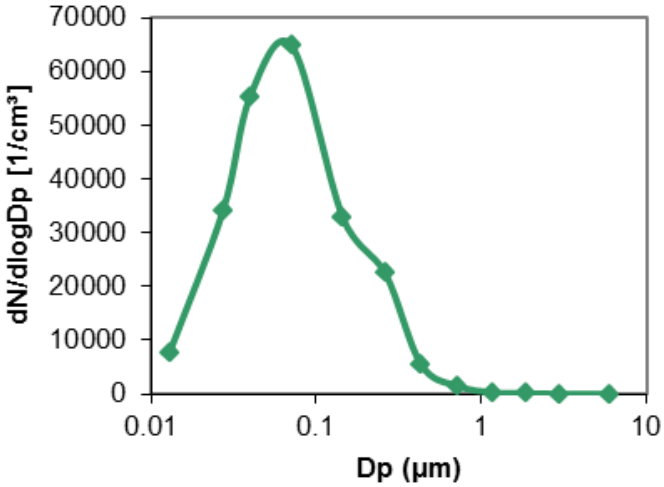
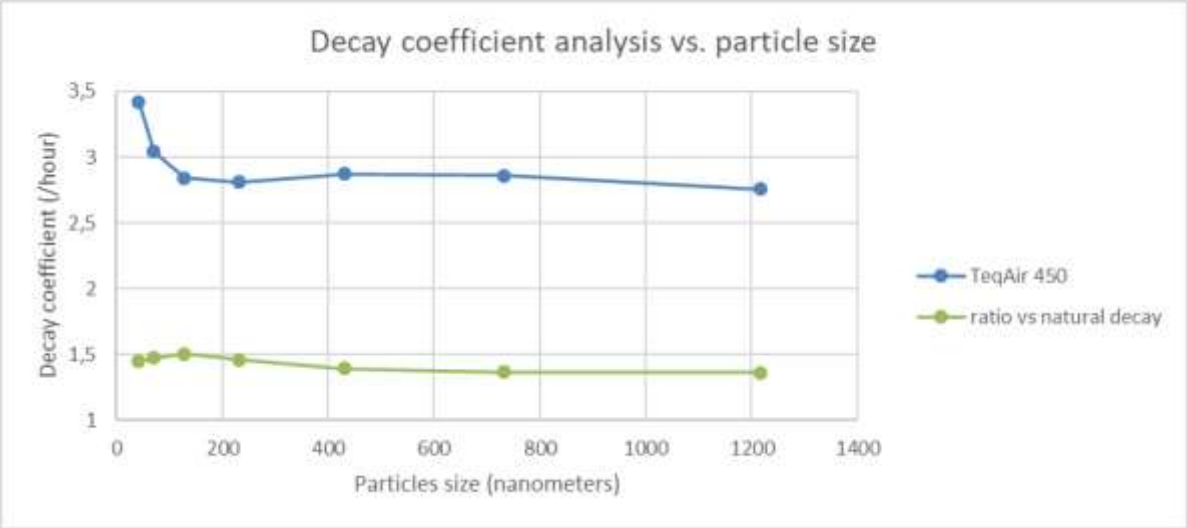


FIG. 3 – PARTICLES SIZE SPECTRUM

Their distribution in mass fraction shows a significant shift of the center to a size slightly less than 1 micron, the relative mass of the larger particles being greater than that of the finest.

Efficiency was calculated for some particle sizes. The below figure illustrates that the ratio between decay coefficient with/without the system under test, is quite stable across the particles size range. (The increase of decay speed for the smallest particles is probably due to the particles diffusion, which is important at nanometric scale.)



3 CONCLUSION

Teqoya TeqAir 450 ionizer has a very significant impact of particle decay.

In a room of 75 m^3 (area 30 m^2), the particulate concentration is divided by 2 after 40 minutes of testing.

The analysis of the data from the ELPI granulometer showed that this efficiency does not depend on the size of the particles in the range covered for this study (40 nm - 1 µm).

The CADR is estimated at 154 m^3/h in the test device used.