# Aerosol separators and aerosol and grease treatment systems

In order to remove the grease from extracted air and thus prevent a build-up of grease and dirt in the ventilation ducts, commercial kitchens are fitted with aerosol separators (a.k.a grease/vapour separators or grease/vapour filters). These metal based aerosol separators comply with the VDI guideline 3676 for centrifugal separators.

**Aerosol**
The term aerosol refers to both liquid and solid particles dispersed in air. As regards aerosol separators, it generally describes droplet aerosols as the particles in kitchen fumes are made up of fat, oil and water droplets. Due to the high temperatures and/or the relatively low steam pressure of these components, they are also proportionally present in a gaseous state in the air [1, 2].

Odorants in particular are usually gaseous and therefore can't be eliminated with the aid of an aerosol separator. Aerosol is not only characterised by its composition, but more specifically by the particles' size distribution, density and concentration.

Test aerosol in use according to UL 1046 testing

**Influential factors for aerosol separation**
For the purpose of separation, the so-called aerodynamic diameter is used to represent an equivalent diameter for particles of irregular form and density. It is defined as the diameter of a spherical particle with a density of 1000 kg/m3 and the same settling velocity as the irregular particle being measured. As aerosols don't consist of particles with a fixed diameter, in separation a so-called fractional efficiency curve is used, which reflects the separation efficiency based on the particle size (Determined by VDI 2052-1).

In centrifugal separators it is predominantly the inertial force of the particles in a moving gas stream that is used for separating the aerosols. The vapour and aerosol separators in kitchens are deflecting separators, which steer the air stream into manifolds or around obstacles (e.g. deflector plates) so that the particles' inertia causes them to leave the streamline. The effect of the inertial force can be increased by gravitational pull.  Centrifugal separation refers to applications in which the centrifugal force caused by radial deflection, such as in a cyclone, is utilised to separate the particles.

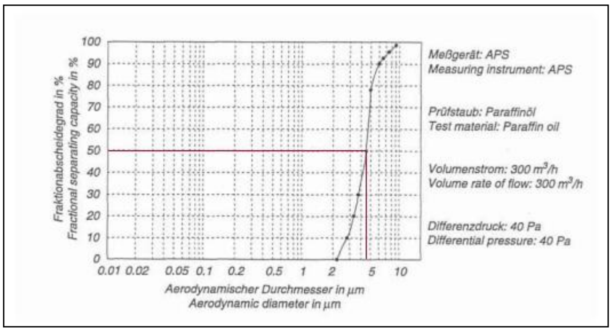
Because the inertial force is proportional to the particulate mass, but the mass is cubically proportional to the radius ($r^3$), as the particle size is reduced, the inertial force can drop significantly. Diffusion force only begins to affect separation if the particles have a size of 0.1 µm or below, meaning it is difficult to remove very fine aerosol particles using an aerosol separator. Firstly, a very rapid airflow is necessary and/or the airstream must be drastically deflected in order to enable effective inertial separation. Further disadvantages are the higher noise levels and the increase in energy consumption due to the loss in differential pressure. On the other hand, if the speed of the airstream is too great, the already separated liquid could be pulled away from the walls.

Vapour/aerosol separator in DIN 18869-5 test rig

## Characteristics of a good aerosol separator

As well as good separation efficiency, an aerosol separator fitted in a kitchen should also act as an effective flame resistor in case of fire. The challenge here lies in meeting both these requirements while still being able to produce effective separators at a reasonable cost.

The particle diameter known as $d_{50}$ refers to the diameter at which the separation efficiency is 50% (or T:0.5) as shown on the fractional separation capacity curve (see diagram). This is often the cut off point.




Graphical representation of fractional separation capacity (Excerpt from VDI 2052-1, p. 10). The separation efficiency ($d_{50}$ value) in this example is approximately 4.5 µm.

## Characteristics of kitchen aerosols

Investigations into the particle size distribution of kitchen aerosols [1] established that the composition varies depending on the cooking appliance used (i.e. the process, such as roasting or frying), the type of kitchen (canteen, restaurant etc.) and the distance from the point of origin. Results showed aerosol concentrations of between 0.1 mg/m³ and 6 mg/m³ at the work stations and 2 mg/m³ to 60 mg/m³ in the extraction hood in front of the aerosol separator. When frying in a pan the average particle diameter at the work stations was determined as roughly 2 µm, but as little as 0.5 µm when carrying out extremely hot processes such as grilling. On the way to the extractor, however, high-concentration aerosols can agglomerate, increasing the size of the liquid drops, as was found to be the case when frying steaks. Here a diameter of approximately 30 µm was recorded just in front of the separator [1]. On the other hand, diverse measuring in kitchens showed that on average 80% of the aerosol mass contained particles with a diameter of between 0.1 µm and 8.0 µm[3].

Despite the findings of the investigation, the statistics on particle size distribution in kitchen aerosols are still insufficient in order to reliably determine the separation efficiency required for an aerosol separator to achieve a mass reduction of e.g. ≥ 90 %. Although commercial kitchens are spreading, to date there have been very few investigations on the topic of aerosol distribution and composition or how to efficiently separate aerosols.

Some more intensive investigations on the gas-phase composition of kitchen fumes do exist  [2, 4], – namely concerning the gaseous products of kitchen processes, their mass rate and distribution in the kitchen – however, knowledge on the efficient reduction of kitchen fumes is severely lacking.

Taking an aerosol sample during testing according to LPS 1263 standard


[1] Rietschel et. al. “Airborne pollutants in commercial kitchens. Assessment and prevent measures. Particle size distribution and composition of aerosols” Proceedings Dust, Mist and Fumes, Symposium Toulouse 2001

[2] B. Andrejs et al., „Influence of ventilation system on aerosol and vapour concentation in the kitchen”, Indoor Air 1999

[3] W. Sterk, “ Bestimmung der Größenverteilung von Partikeln in Küchenaerosolen“, Diplomarbeit  1994, Inst. Mech. Verfahrenstechnik und Mechanik TH Karlsruhe/BGN

[4] B. Andrejs „Luftfremde Stoffe in Küchen“ VDI Bericht 1818, 2004, S. 1-7



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