Understanding Kitchen Ventilation

Measuring and controlling airflows

REVEN
SCHAKO Group

WHO IARC results on the study for cooking fumes

In 2010, the International Agency for Research on Cancer (IARC) of the World Health Organization (WHO) published the IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 95, with the title "Household Use of Solid Fuels and High-temperature Frying".

In the IARC monographs, Volume 95, the following is noted:

"'Cooking fumes' or 'cooking oil fumes' is the term commonly used to describe the visible emissions generated during cooking by frying with oil. However, these emissions are not technically 'fumes'. In occupational and environmental hygiene, 'fumes' are defined as submicron-sized solid particles (particulate matter) created by the cooling of hot vapour. During cooking, such vapour is formed when the cooking oil is heated above its boiling point. In addition to this ultrafine particulate matter, cooking, especially frying and grilling, generates aerosol oil droplets, combustion products, organic gaseous pollutants, and steam from the water contents of the food being cooked. [...]

Cooking, in particular frying, generates substantial amounts of airborne particulate matter (PM), which includes ultrafine particles (UFP) and fine PM (PM2.5), and is a major contributor to their indoor levels. In addition, particles created during cooking have organic substances adsorbed on their surface. These include polycyclic aromatic hydrocarbons (PAHs) and heterocyclic amines. Certain gaseous pollutants such as formaldehyde (IARC, 2006), acetaldehyde (IARC, 1999), acrylamide (IARC, 1994) and acrolein (IARC, 1995) are also produced during cooking."

Overall evaluation: Emissions from high-temperature frying are probably carcinogenic to humans.

Note that a person needs about 12,000 litres of air, breathing in and out within 24 hours and spending up to 8 hours working in a commercial kitchen, with the above noted air pollution problems! These data show how important it is to install a truly functional kitchen ventilation and really validate its function.

Basic features and the function of a kitchen ventilation must be documented and measured, these include:

1) The separation efficiency of a kitchen ventilation
2) The capturing efficiency of a kitchen ventilation
3) Trouble-free supply airflows
4) The intelligent control of the kitchen ventilation with the help of sensor data

The Essentials of Kitchen Ventilation

Exact measurements of the performance of separators, extractor hoods and air supply units are essential for the functionality of kitchen ventilation systems!

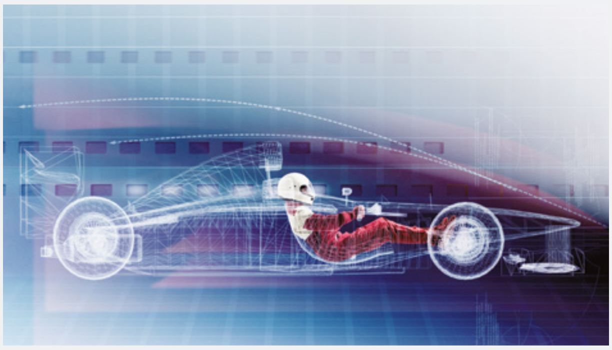
Airflow and air purity measurements

Based on scientifically sound methods
We leave nothing to chance where the functionality of kitchen exhaust systems is concerned! Highly sophisticated measuring equipment, software and development tools are used to continuously improve and optimize our fume extraction and kitchen ventilation systems.
We examine thoroughly the behaviour of the exhaust airflows and the particles they carry along with them.

All our products pass through a development process of several years and we use the following technology and equipment to support optimization:

- Software systems for numerical flow mechanics
- Flow laboratory with scattered light spectrometer system
- Flame ionization detector (FID)
- Laser photometer and data logger
- Thermal imaging systems with high resolution

CFD simulation is of utmost importance. It is currently the only method that allow us to understand and measure the behaviour of airflows. For more than 25 years, we have continuously analysed and improved our X-CYCLONE® and REVEN® systems!



What does CFD stand for?

CFD (Computational Fluid Dynamics) is a numerical method to simulate and visualize complex airflows. Among various other applications, it is used to check the functionality of construction components and to improve them.

Designers of airplanes and racing cars, for instance, use this technology to optimize airplane wings or car spoilers.

Benefits of CFD

The great benefit in comparison to experimental methods and measurements lies in the fact that CFD maps all physical entities together in their interaction and provides evidence of the functioning instead of delivering values merely for selected points. This technology allows us to prove the performance of our ventilation systems.

Automatic airflow control

In the smart kitchen 4.0
When we developed our RSC technology, we strived for a healthy indoor climate in commercial kitchens while keeping an eye on economy. With the help of sensors, the smart RSC control system ensures the continuous automatic control of the supply and exhaust air as well as of the extraction power in accordance with the innovative Industry 4.0 standard. The system adjusts the ventilation continuously to the cooking activities in the different cooking zones.

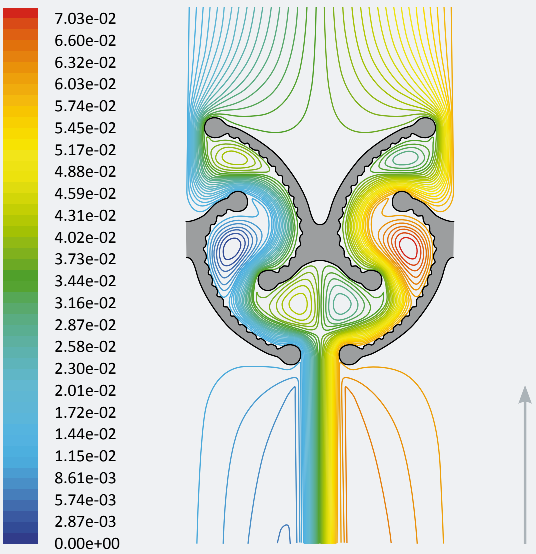
**Clean air and a healthy working environment –
the capture and separation of air pollutants is our core competence!**

Brought to perfection by CFD analysis

The behaviour of airflows plays an essential role in kitchen ventilation. The capture of the cooking fumes, the separation of the aerosols in the separators and the air supply to the kitchen, all these functions are determined by the behaviour of the airflows.

Separation of aerosols

X-CYCLONE® Separators



Contours of Stream Function (kg/s)
The different particle sizes are identified by different colours.

Detail of an X-CYCLONE® separator. The separated oil particles form droplets and run down to the bottom.

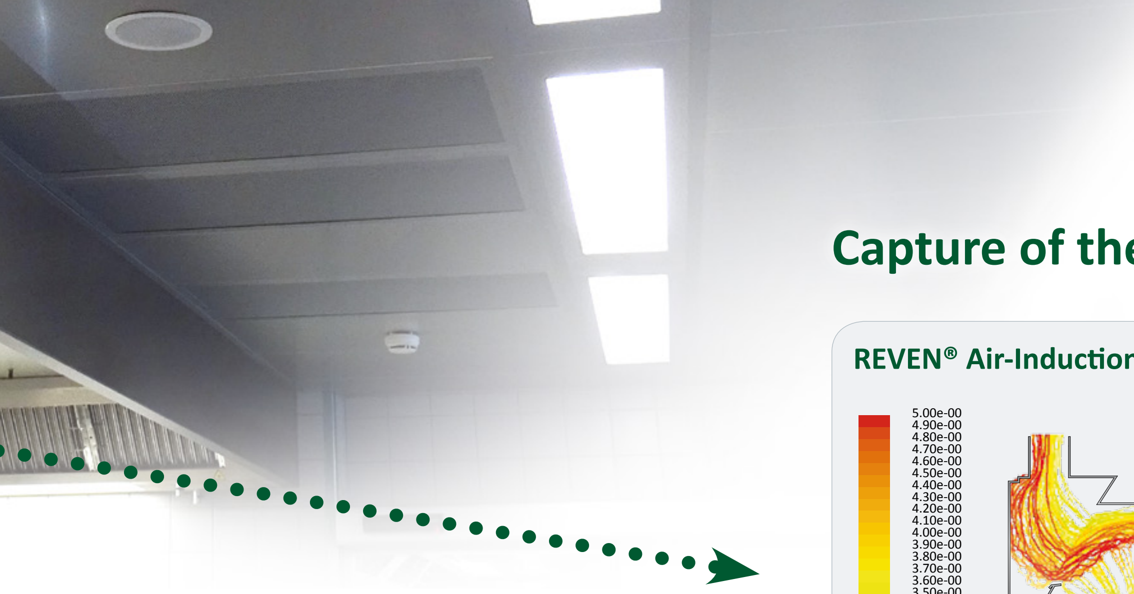
Separation of aerosols

In the process of optimizing our extraction equipment, we first analysed the flow behaviour of the airborne oil-based and particle-based aerosols in the X-CYCLONE® separator with CFD (first CFD diagram on the left) and gained important insights.
Airborne pollutants do not always behave like the air molecules.

The interplay between the shape and surface of the X-CYCLONE® profile and the condensed air or aerosol flow plays an important role and ensures the best possible separation of pollutant particles and oil droplets. Our optimization efforts with CFD have recently brought about the fifth generation of our X-CYCLONE® profile with arrow geometry, which is protected by patent rights worldwide.
The separating rate amounts to 99.9999 %.

Often not mentioned, but indispensable to achieve the high separation efficiency, is the condensation of the different air or vapour molecules in the exhaust air before it flows through the separator.
When using our REVEN® EFF system or the REVEN® air-induction system (see graphic on the right, adjacent page), this happens almost incidentally. The temperature of the supply air used for air induction is at least 30 °C below that of the cooking fumes which were heated up to 60 to 80 °C. Hence, the desired condensation is inevitable.

If there is no condensation of the cooking vapours upstream of the separator, the exhaust air, which is heavy with grease and water, condenses in the exhaust air duct, creating a fire hazard and a breeding ground for bacteria, not to mention the possible formation of odours.

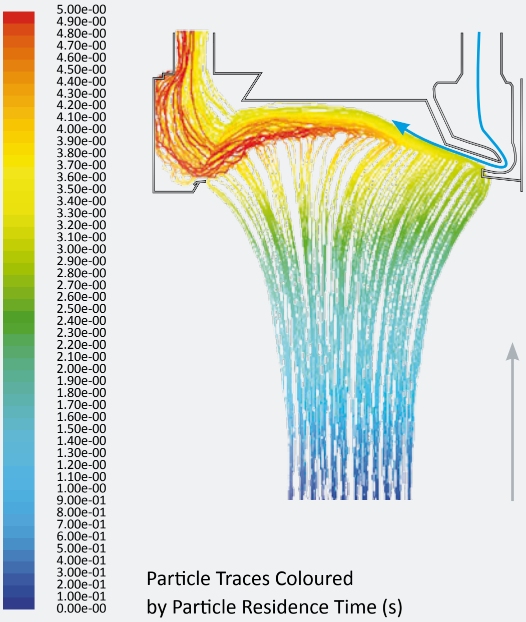


Capture of the exhaust air

Capture and condensation of the exhaust air

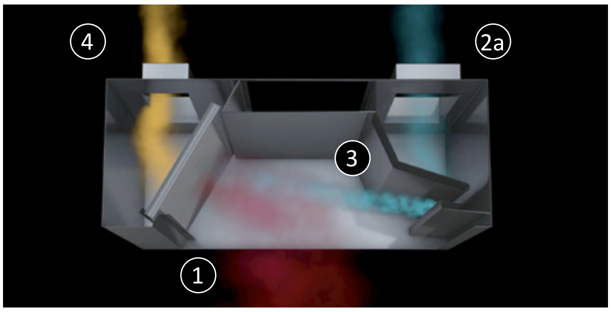
In a second step, we investigated by means of CFD the residence time of the kitchen fumes and airborne aerosols inside the extractor hood to find out how we can optimize the airflow behaviour in the extraction process with air-induction (second CFD diagram on the right). The result is our **efficient**, **REVEN® air-induction system,** which is a standard component of most of our fume-capture systems and protected by patent rights worldwide – because **blowing is more efficient than sucking.** Brand new on the market is the **REVEN® EFF system** also with a worldwide patent.

REVEN® Air-Induction System

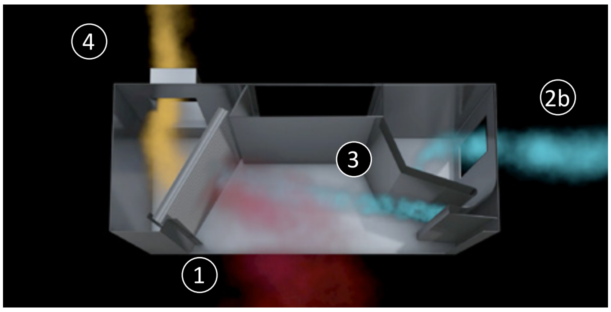


Particle Traces Coloured
by Particle Residence Time (s)

Air-Induction System



EFF-System



1: Cooking vapours 60 - 80 °C (red)
2a : Untempered filtered outside air used as supply airflow (blue)
2b: Indoor air at indoor temperatures is sucked in for the supply airflow (blue)
3: Induction airflow draws cooking vapours to the separator and causes air molecules to condensate (blue)
4: Cleaned exhaust airflow (yellow)

In contrast to the first induction system, in which untempered outside air is fed into the hood via a supply air duct, the supply air for the REVEN® EFF system is generated from the kitchen air.

If the air exchange rate is high, we still recommend the REVEN® induction system. The air exchange rate is influenced by the size of the kitchen in relation to the number of cooking appliances, the connected load (kW) and the location of the supply air devices.

Without an air-induction system, a normal kitchen hood cannot extract all the cooking fumes through the separators during intensive cooking phases. Harmful airborne particles such as smoke and oil aerosols can escape into the kitchen and be inhaled by the kitchen brigade.

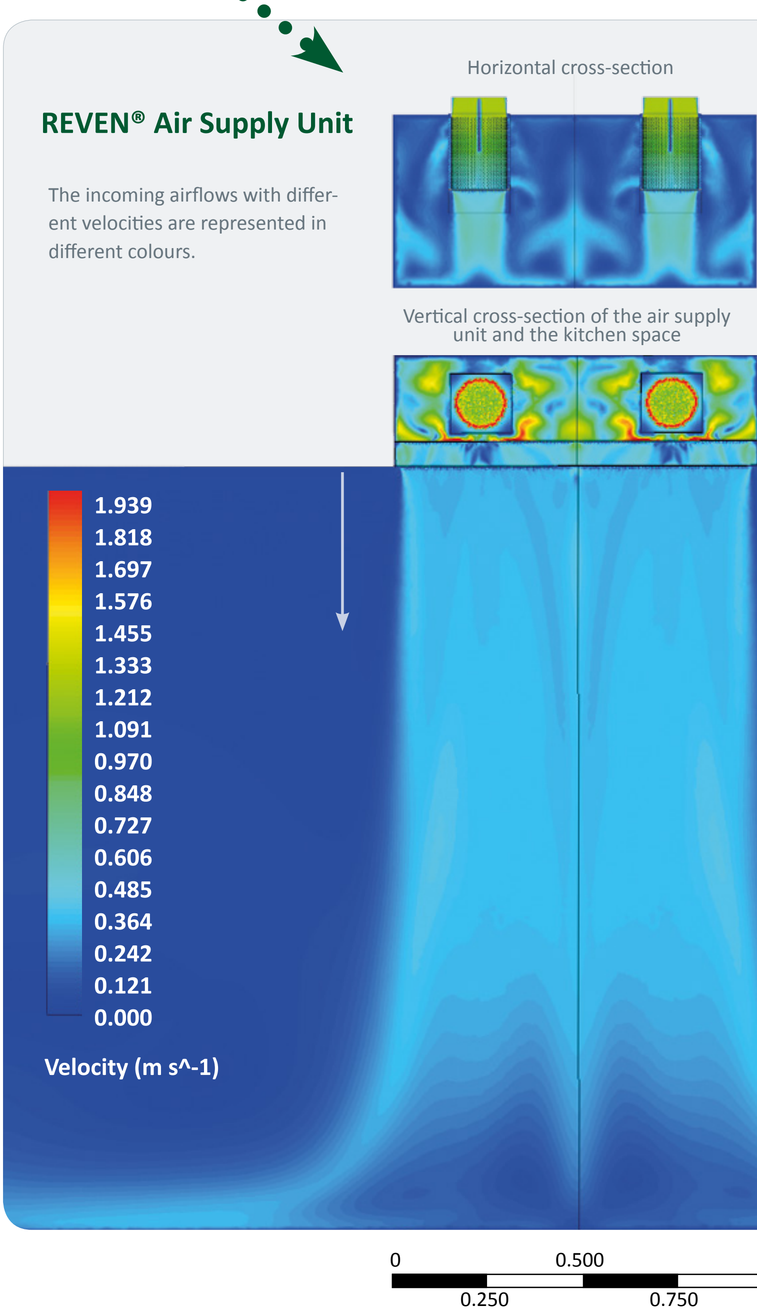
Air supply equipment with

The latest CFD analyses of the REVEN® ECOJET and REVEN® DQA air supply units produced amazing results.

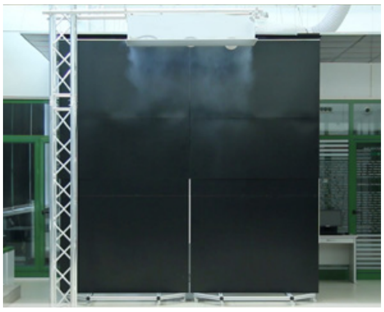
Feed of supply air

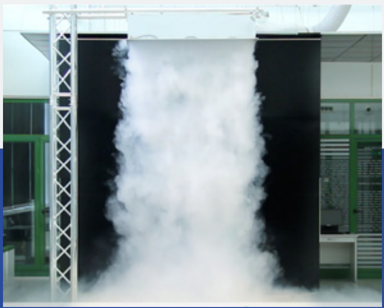
The latest CFD analyses of the behaviour of the airflows in our air supply units and, especially, of the supply airflow in the kitchen space confirm our expertise: The smooth feeding of air into the kitchen is prepared in the air supply unit. The airflows out of the low-velocity air outlet almost straight downwards to the kitchen floor. There is no vortexing with cooking fumes and the extraction process in the capture hood is not disturbed or hindered in any way. Moreover, draught is avoided (third CFD diagram on the right).

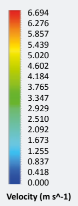
Feed of supply air



optimized airflow







Kitchen space

Photos above:
Visualization of the supply airflow behaviour in the kitchen space when using a REVEN® ECOJET unit, installation height = 3.50 m.

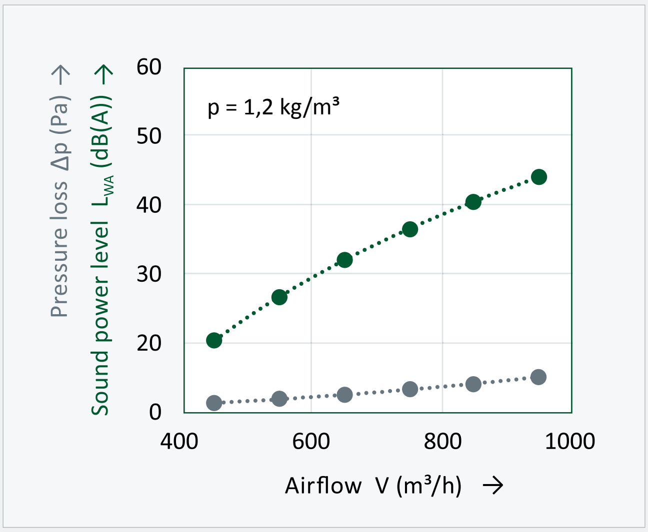
Diagram on the left:
CFD simulation of the supply airflow in the kitchen space when using a REVEN® ECOJET unit.

The behaviour of the supply airflow fed by a REVEN® DQA unit is the same as with a REVEN® ECOJET unit, in the laboratory test as well as in the CFD simulation.

1. 000 (m)

REVEN® air supply equipment is whisper quiet.

Development of the pressure loss and the sound power level with increasing supply flow rate

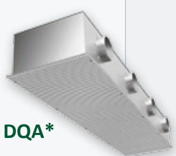


Both, the pressure loss and the sound power increase slightly, proportionally to the flow rate of the incoming air.
With a sound power level of approximately 45 dB(A) at the highest flowrate, the REVEN® ECOJET and DQA units are as quiet as a whisper and would be suitable for operation in a public library.

Sound pressure level L_P

Comparison of different sound sources

140 dB (A)	Jet aircraft
130 dB (A)	Threshold of pain
120 dB (A)	Thunderstorm
110 dB (A)	Jackhammer, percussion
100 dB (A)	Train, ghetto blaster
90 dB (A)	Lawn mower
80 dB (A)	Car motor, piano play
70 dB (A)	Electric hair dryer, water cooker, vacuum cleaner
60 dB (A)	Normal conversation, office sounds
50 dB (A)	Low-level conversation, refrigerator
40 dB (A)	Whisper
30 dB (A)	Silent bedroom at night, **REVEN® ECOJET & DQA***
20 dB (A)	Mosquito
10 dB (A)	Breathing, rustling of leaves
0 dB (A)	Hearing threshold



* Sound pressure (dB(A)): A sound attenuation of 8 dB(A) has been considered. The level corresponds to an airflow of 750 m³/h.

RSC (REVEN® Speed Control)

Computer-controlled management of the supply and exhaust air as well as of the extraction power.

Technology for automatic control

Kitchen ventilation 4.0

To improve the economic efficiency of ventilation systems in commercial kitchens, we offer the intelligent automatic control system RSC. The system adjusts the speed of the air supply and exhaust fans continuously to the cooking activities, as required by the innovative Industry 4.0 standard.

Temperature and humidity sensors detect the cooking activities in the different zones of the kitchen. The controller increases or decreases the supply airflow rates and the extraction power in accordance with the requirements. At the same time, the required air volumes are distributed over the respective cooking zones via air dampers. The sensor-driven control system allows a reduction of energy consumption costs of up to 50 % and extends the service life of the air cleaners fitted downstream. Moreover, draught is avoided.

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