air & odour management

ENGINEERING BULLETIN – UNDERSTANDING KEY DESIGN/MANUFACTURING PARAMETERS INFLUENCING ELECTROSTATIC PRECIPITATOR EFFICIENCY
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Product Range: FILTRATION EQUIPMENT – ELECTROSTATIC PRECIPITATORS

A range of Electrostatic Precipitators (ESPs) can be found on the market, most of which have been imported from manufacturing countries in Asia. Though the design and the functionality of the units are similar, differences exist within the units that result in significant performance and durability discrepancies. The following document looks at available research in ESP performance and provides a comparison between certain ESP units currently used for the particle filtration of commercial kitchen exhaust.

1. General parameters influencing ESP particle capture efficiencies

1.1 Multiple international studies have been carried out on the means of improving Electrostatic Precipitator (ESP) particle filtration efficiencies – notably since ESPs are one of the main filtration methods for removal of hazardous particles originating from industrial processes (coal burning, etc).

1.2 Skodras (2006) breaks down the main parameters as:

- The Gas Flow Field (pressure, velocities, turbulence): generally, high velocities lead to lower contact times and higher airflow turbulence, significantly affecting the performance of units.
- The Particle History (trajectories, charge, velocities, residence time, fate, etc.) including Eulerian variables (concentration, charge density, etc.): high particle concentrations, dry particles (with higher charging resistances), duct trajectories which influence turbulence and flow balancing all negatively impact ESP efficiency.
- Electrostatic parameters (potential, strength, ion current density): this relates to the capacity of the ESPs to charge and then capture particles and include the electrical and the mechanical parameters of the units.

1.3 Both Gas Flow Field and Particle History parameters are dependent on the effluent that needs to be treated and the way that the particles arrive into the ESP units. These parameters are project specific and are not tied to the design / manufacturing of ESP units.

1.4 The following document will investigate the electrostatic parameters which are influenced by design / manufacturing choices and will review equipment specifications associated to them.

2. General use of Electrostatic Precipitators in treatment of commercial kitchen exhaust

2.1 ESP units are successfully employed for particle filtration of commercial kitchen exhaust, notably because:

- Commercial kitchen exhaust is composed mainly of grease particles and grease vapour, both of which are highly susceptible to electrical charging and therefore electrostatic capture.
- The viscosity of these particles means that they easily precipitate into grease trays generally located below electrostatic cells and therefore these units do not require rapping to remove particles (as used in large coal fire power plant applications).
- The units are generally made in materials adapted to the highly contaminated and corrosive nature of commercial kitchen exhausts and therefore do not increase the fire risk of the exhaust system.

2.2 Electrostatic precipitators used for the treatment of commercial kitchen exhaust have a similar design principle. High voltage is applied to a series of charging electrodes that create a corona charge in which particles pass through. Alternately charge collecting plates then attract particles which precipitate into trays located out of the exhaust airflow.

2.3 That said, minor design / manufacturing parameters can significantly influence the efficiency of the units to charge, capture and then contain particles and ensure their removal from the exhaust airflow. The following document will look into:

- Electrical Voltage
- Electrostatic cell design
- Cabinet design

3. Electrical Voltage

3.1 Multiple international studies have underlined the importance of the applied voltage to the particle capture efficiencies of ESPs. As an example, Skodras (2006) states that research parameters revealed that small particles are harder to collect and that the most efficient way to increase the collecting performance is to increase the wire voltage or lower the entry velocity.

3.2 Voltages generally applied in ESP units for commercial kitchen exhaust systems are in the range of 12-14 kV for charging wires and 6-7 kV for collection plates. This range of applied voltages already generate significant differences in ESP unit filtration efficiencies when a standardised test method is compared (ASHRAE 52.2) at a similar test velocity. This is shown in the below table of a selection of units available on the local market.

Unit (Australian Supplier)	Smog Hog (UAS Australia)	RydAir (AOS Australia)	CFM (CFM Australia)	EAN SCRUBBOX (AOM Australia)
Applied High / Low voltage (as per suppliers' specifications)	11 kV / 5.5 kV	12 kV / 6 kV	13.5 kV / 6.5 kV	14 kV / 7 kV
ASHRAE 52.2 efficiencies for particle range 0.3-0.4 micron	85-90% at 100% rated airflow (link)	91.6 % at 2.54 m/s (link)	91% at 2.59 m/s (link)	95.7 % at 2.97 m/s
MERV Rating	15	15		16

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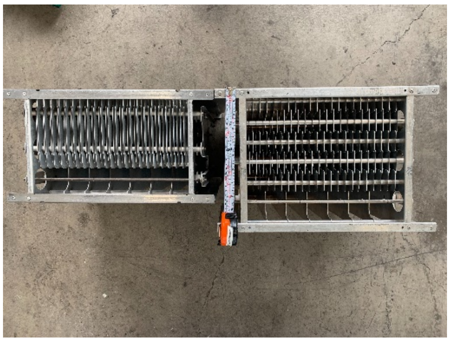
4. Electrostatic Cell design

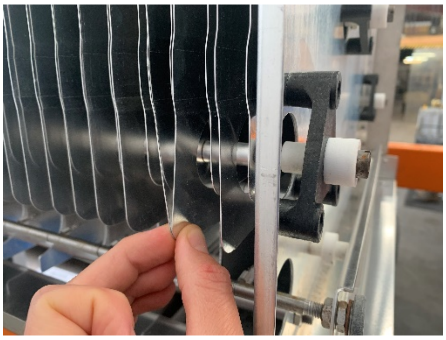
4.1 The design of the electrostatic cell – and notably the collection plate stage, is a recognised means of ensuring high collection efficiency in an ESP unit. Yong (2019) underlined in their testing of two stage ESPs that extending the collection stage and properly shortening the pre-charger are effective ways to improve the dust removal capacity.

4.2 The Babcock.com learning centre states that operational problems significantly influence the performance of ESP units. The main one of these being warper collecting plates which cause electrical shorts which results in stops to the electrostatic cell's power supply as well as increased electrical faults in the units.

4.3 Overall, the electrostatic cells are a vital component of the ESP filter. Electrostatic cell manufacturing will influence the long-term equipment performance, notably since cells require manual handling for cleaning purposes and as such are subject to mechanical damage. Cells are generally manufactured in aluminium (5052 grade has good corrosion resistance properties), but low-grade aluminium cells are found on the market. These generally result in material rusting early in the equipment life span.


Low grade aluminium cell showing signs of rust in a RydAir unit (AOS Australia).


Significant difference in cell sizes between the CFM unit (left) and the SCRUBBOX (AOM Australia) electrostatic cell (right).


Thin aluminium collector plates (0.5-0.6 mm) that easily bend as found in RydAir units (AOS Australia). The SCRUBBOX units (AOM Australia) have 1mm plates which cannot be bent.

5. Cabinet design

5.1 A major parameter to the overall performance of an ESP is the ability of the unit to limit particle re-entrainment into the airflow. Studies carried out on ESP units used for coal ash filtration have shown that up to 12 % of fly ash can be re-entrained into the airflow after having been collected, due to the unit's inability to contain particles (see EPA/452/B-02-001 (1999)). These units depend on rapping to dislodge particles from plates and collect them in a mechanical collector.

5.2 Grease particles found in commercial kitchen exhaust have high viscosity, notably at temperatures found in commercial kitchen exhaust ducting. This means that ESPs can benefit from gravitational flow to direct the collected grease particles towards an in-built mechanical collector (generally a grease tray), in order to ensure that the particles are removed from the ducting (decrease the fire risk of the exhaust system) and to decrease the risk of re-entrainment of particles.

5.3 In certain projects, a well-designed commercial kitchen exhaust filtration system can filter out and remove from the ducting and airflow up to 2-3 litres of grease per day. This can only be achieved if the ESP cabinet is designed with an internal slope that allows grease to flow into a collection tray. This is not a standardised feature of all ESP units currently available on the market, meaning that certain units are not able to contain and evacuate grease, but ultimately increase the build-up of grease in the exhaust system.


Rydair unit casing (AOS Australia) show no internal slope or internal grease capture capacity meaning the unit increases the build-up of grease in the exhaust system. Unit is made in 1.4mm galvanised steel.

SCRUBBOX unit (AOM Australia) showing the internal grease tray which is located under the unit and out of the exhaust flow. An internal sloping system means that these units extract up to 2-3 litres of grease per day in certain applications. The units are made of 2 mm galvanised steel meaning that they are more durable than the RydAir units.