1. **Air Clean in Air Handling Units**

The filtration system consists of a combination of electrostatic filtration cassettes (EFX) and negative air ion emitters.

Thanks to the low pressure drop created by these systems, the energy consumption will be much lower than in AHU equipped with classical filters.

The proposed solution, consisting of the **Air Clean** system, is to be installed in available sections of the air handling units. The suggested length, towards the air flow direction, is approximately 1.1 - 1.2m and located before the heating and cooling coils.

In this case an additional 0.3m section has to be considered after the heating or cooling coils to ionize the flow downstream of the unit.

Additionally we propose **a combination of the Air Handling Unit and the Air Clean system**.

1.1 The Air Clean Sanitation System

1.1.1 **Air Clean** Air Sanitation Process - a natural phenomenon

The **Air Clean** Air Sanitation Process is based on the natural decontamination process of a lightning, producing high concentration negative air ions (= oxygen molecule + one electron) and a micro concentration ozone, building together a kind of “cold plasma”. It has been scientifically proven that:

- high concentrations of negative air ions (NAI) is extremely healthy since they naturally boost the blood with oxygen and activate our vital systems
- the plasma produced by a lightning has a bactericidal effect

The micro-concentration ozone is produced by the electrostatic filters and the high concentration NAI by the NAI emitters, that are spread in the downstream side of these fllters, in the AHU and in the ducts.

The combination of these two technologies in order to re-create the lightning effect is a process called “**Cold Plasma**”.

The drawing in the last page illustrates the **Air Clean** concept:

- The **electrostatic filters** remove the fine particles down to 0.1µm and already killed microorganisms present in the incoming air.

- The **air ion emitters** produce high concentrations of NAI which, in combination with the microconcentration ozone, will kill the micro-organisms that have escaped to the electrostatic filters and prevent any micro-organism growth on the surfaces on their downstream side.

The **Air Clean** concept has the following advantages:

- it destroys the airborne micro-organisms before they can contaminate the air distribution system
- it prevents any micro-organism development in the Air Handling Unit and in the downstream ducts
- ions are continuously produced when the AHU is working
- it does not generate toxic compounds like NO_x or excessive quantity of ozone

In the low atmosphere of the earth, negative air ions and micro-concentration ozone are naturally present, thanks to the 2000 lightnings produced every second around the earth and to the release of erectrons from the earth´s crust. The Negative Air Ion concentration varies from 25 up to 100,000 NAI/cm^3.

Negative Ion Emitter mounted after the electrostatic filter
The negative ion generation adjusts the particle separation down to 0.1 micro.

In combination with the assembly before the filter, this method contributes in a positive way to:

- Extremely good clean air
- Clean air ducts
- Good energy savings
- Maintaining the right balance between positive and negative ions
- Minimal maintenance – Low life cycle costs with energy savings
- Saving of the Earth´s resources

The potential health hazard that can occur when changing the pocket filters is avoided with this system.

Electrostatic filters always provide operational status and alarms.


Before negative ion generation


After negative ion generation

1.1.2 **The electrostatic filters**

Electrostatic filtration is a well established two step particle abatement technology for separating very fine particles and aerosols as small as 0.1µm, without creating pressure drop increasing with time.
The **first step** called "ionizing section" consists in positively ionising the contaminating particles at around 7kV via tungsten or stainless steel wires.

The ionisation step of the electrostatic filter produces a micro-concentration of ozone, that will react with the negative air ions produced after the filter. The combination of the two is called **Air Clean**, a system which has a strong bactericidal effect on micro-organisms.

The **second step** called picking up section, consists of forcing the ionized particles to flow between aluminium plates, alternatively grounded or positively charged. When a positively charged particle flows between two plates, the positively charged plate repels the positively charged particles on the grounded plate.

These two steps take place in a so called "electrostatic filtration cell" (EFX cell or cassette).

Electrostatic cells.

Contact with plates provokes the destruction of any micro-organism avoiding formation of endotoxins.

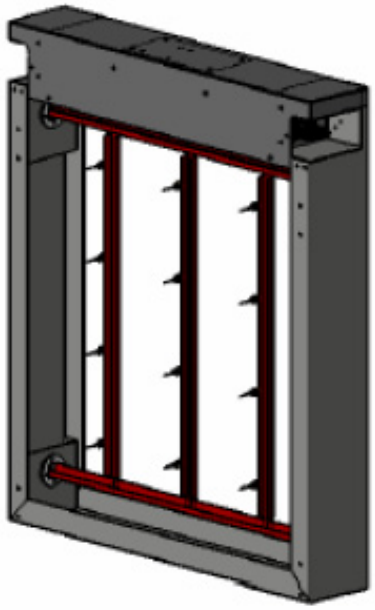
This is the reason why filtration is called "active": it doesn't allow microbes to remain "in action" and to flourish on the intermediate filter.

It also prevents the emission in the environment of substances arising from metabolism and destruction of captured microbiar flora.

In general, the efficiency of one row of electrostatic filters is about 93% on particles > 0.5µm. The efficiency of the two rows solution is above 99%.

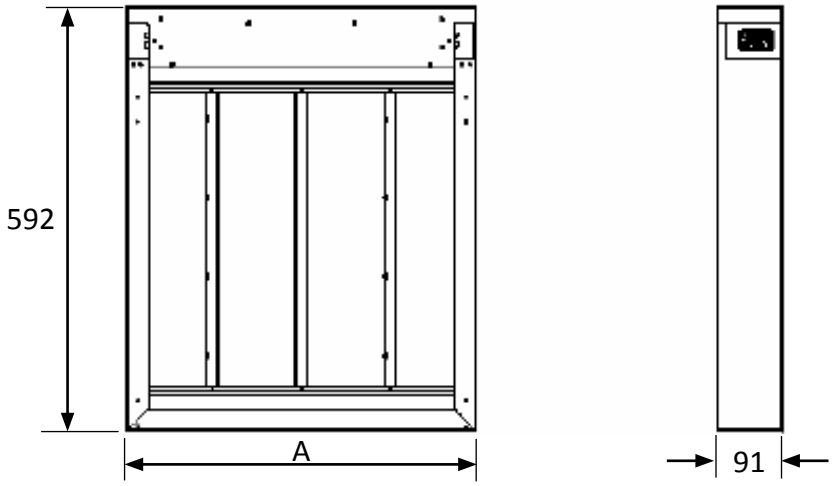
1.1.3 The Negative Air Ion Emitters

High concentrations of negative air ions are produced by Negative Air Ion Emitters, consisting of gold coated needles, blowing electrons into the electro-filtered air that will instantly bind on oxygen molecules and form negative air ions (NAIs).



Negative Air Ions are essential for human beings since they naturally boost the blood with oxygen.

This cell can be installed in sliding frames inside the air handling units with an electric supply at low voltage (220V) as with the electrostatic filters ones.



NAI 287 - A = 287
NAI 500 - A = 500
NAI 600 - A = 592

1.1.4 Validations

1.1.4.1 Validations on microorganisms in laboratories

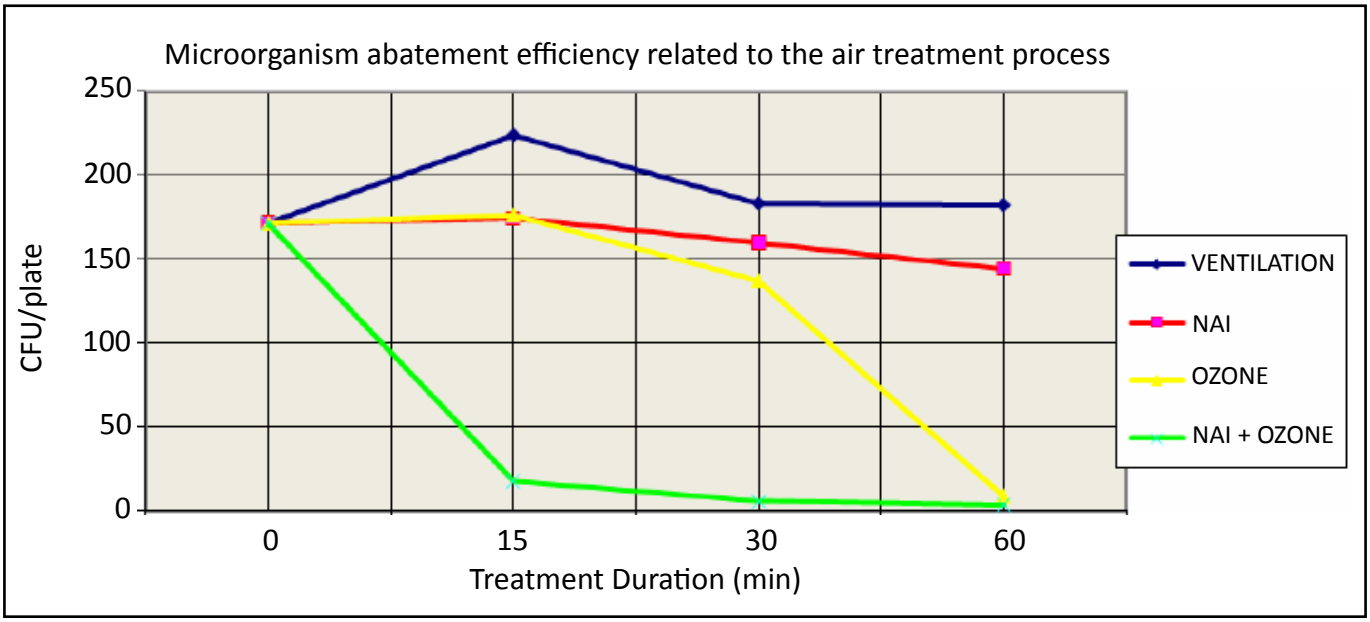
The validations have been performed at the Veneto Agricultura (Thiene, I) and the Dep. of histology, microbiology and medical biotechnologies of the University of Padova.

The aim of the first validation was to prove the higher bactericidal efficiency of the **Air Clean** concept compared to a high concentration of NAI ($10^6/cm^3$.

Plates, contaminated with *L. innocua*, have been set in an incubator (T = 17°C, RH = 90%) with air circulation. The following air treatment processes have been tested:

1. Air flltration
2. Air filtration and NAI emission ($10^5/cm^3$)

Every 15 minutes one plate has been removed and set in an incubator for later colony counting. The following graph clearly shows that **the Air Clean concept is significantly more efficient than a micro-concentration ozone or a high concentration NAI.**



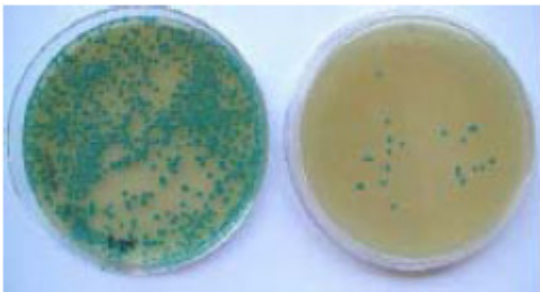
The aim of the second validation was to test the abatement efficiency of the **Air Clean** concept on specific strains like *Staphylococcus aureus, E.Coli, Legionella, Lysteria, Mucor, Penicillium* etc.

Plates contaminated with these strains have been set in incubators or cold rooms, either treated with or without the **Air Clean** concept.

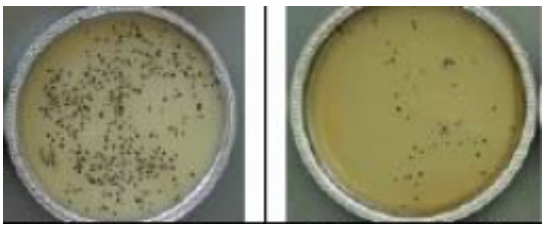
For some strains, like *Lysteria* and *Legionella*, drastic abatements have been obtained after just a couple of hours. For fungi like *Penicillium*, the **Air Clean** concept inhibits the sporulation of its spores.

Strain	T°	Abatement
Bacteria *E. Coli*	4°	94% after 25h
Legionella	35°	98.4% after 4h
Lysteria	4°	96% after 8h
Staphylococcus aureus		
Fungi *Mucor Javanicus*		90% after 48h
Penicillium		Sporulation inhibition after 24h

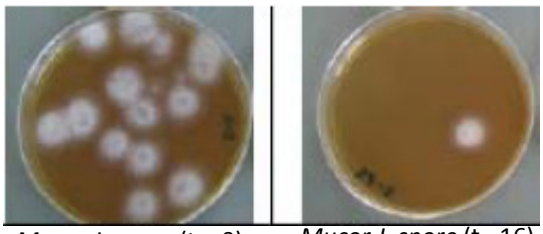
E. Coli (t = 0) *E. Coli* (t = 24)



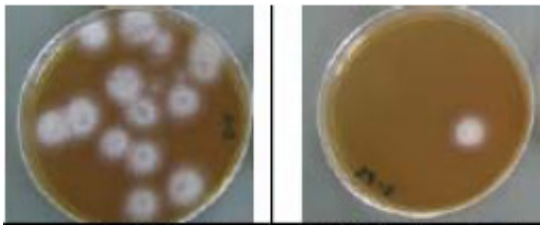
Lysteria (t = 0) *Lysteria* (t =8h)



Staph. aureus (t = 0) *Staph. aureus* (t = 24h)



Mucor J. spore (t = 0) *Mucor J. spore* (t =16)

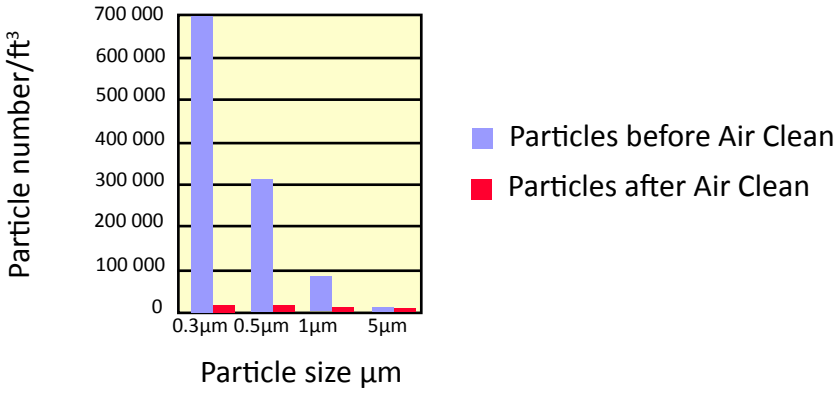


(t = 0) *Penicillium spore* (t = 24h)

1.1.4.2 Validations in the Health Sector

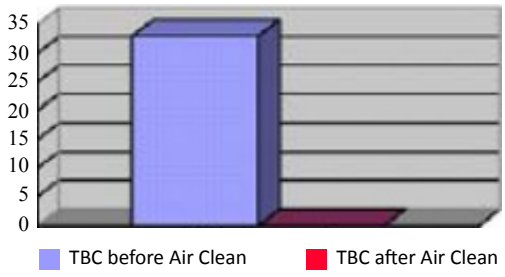
In 1999, at the San Matteo hospital (Pavia, I), the **Air Clean** system was installed in an air duct leading to an operation theatre after an F7 filter and before an HEPA filter. The validation results are reported below:

Particle abatement:

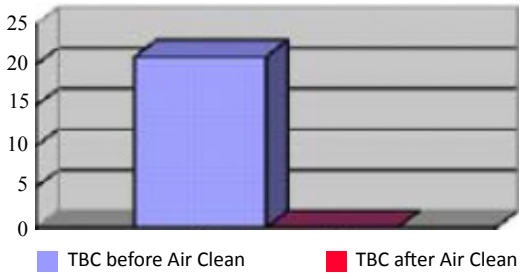


Abatement higher than 99.9% for particles larger than 0 3µm

Particle abatement:



Total Bacteria Concentration
in 1 m^3 air (TBC/m^3)
before and after **Air Clean**

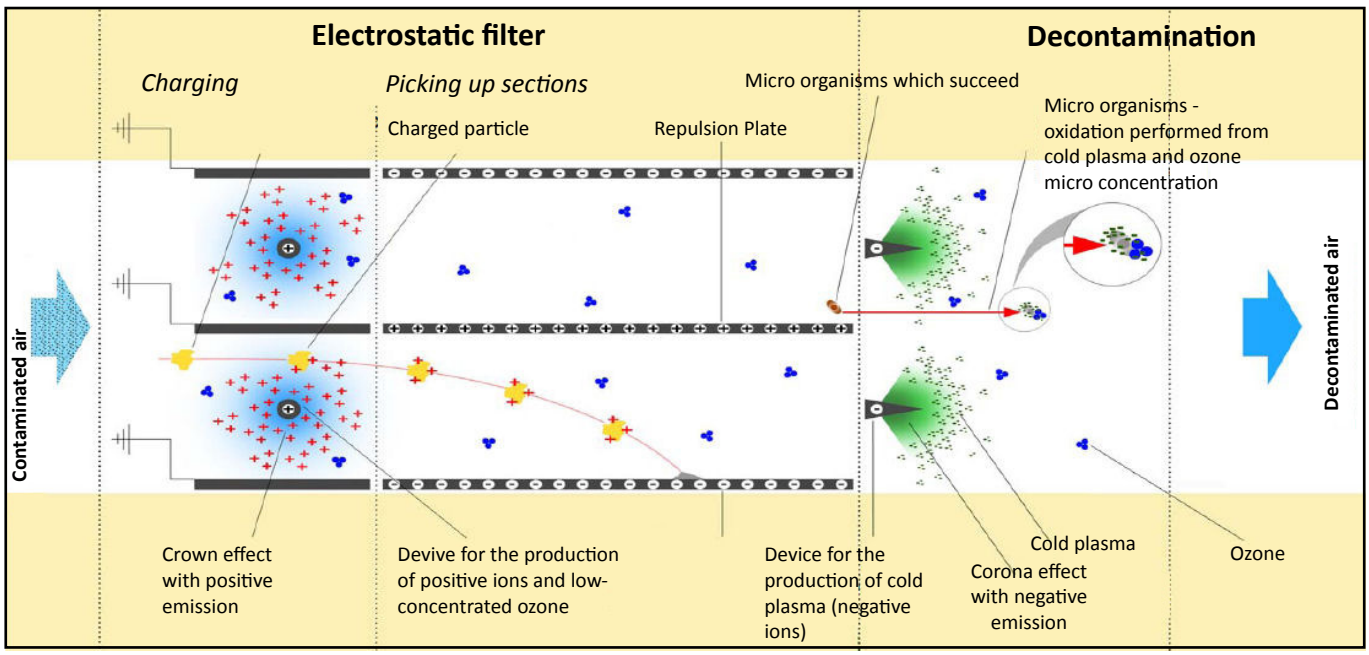


Total Bacteria Concentration
on 25 m^2 duct surface (TBC/m^3
before and after **Air Clean**

Abatement is close to 100% for micro-organisms in the air and on the duct surface.

Other tests have been performed at the “INSTITUT FÜR LUFTHYGIENE” in Berlin. They were related to the efficiency of the prototype system on germs at various conditions.

These documents are available on request.



Below, some gases, which are affected in a decreasing or an increasing degree by ionization:

- Acetone (reduction)
- Ammoniac (reduction)
- Benzene (positive change)
- Butane (positive change)
- Carbon Monoxide (reduction)
- Hydrogen Cyanide (reduction)
- Methane (reduction)
- Nitrogen Oxide (reduction)
- Nitrogen Dioxide (reduction)
- Nitrous oxide (reduction)
- Styrene (positive change)