



Plasma Air 600 Series Demonstrates Improvement in Indoor Air Quality by Reducing VOCs and Virus Size Particles

Chemical test performed by:

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Testing location:

The Zaragoza Trams

Zaragoza tram system serves the city of Zaragoza, the fifth largest city in Spain.



OBJECTIVE

The objective of this third-party study was to evaluate the effectiveness of the Plasma Air 600 Series (PA604 model) at reducing airborne pollutants, specifically 54 VOC compounds, seven Aldehyde compounds and PM levels spanning 0.3 and 0.5 micron (which represent the size of virus particles), in a "real world" environment. The tests were carried out inside two tram cars of the TRANVÍA ZARAGOZA fleet in Spain. Measurements of Ozone, Formaldehyde and Nitrogen Dioxide were also taken to ensure there was no increase.

METHODOLOGY

The methodology of the testing is as follows:

- The interior volume of the tram cars (not counting the two driver cabins) was 159 m³ (5,615 ft³)
- The tram cars used two stand-alone ceiling fan coil units that distributed the air through ductwork to the interior of the car – what is typically the occupied areas
- The system had an external air intake grid with manual control gate and filters rated G3/G4 (MERV 5 to MERV 8). Each air conditioner had a nominal flow rate of 2,150 m³/h (1,265 CFM), and therefore the tram's ventilation system provides 27 air changes per hour (ACH)

REFERENCE STANDARD

Indoor air quality (IAQ) parameter testing was performed in a "real scenario" under the following tram operating conditions:

- Trams had been "unclean" (*) and were in use more than one full day (before measurements)
- No passengers were inside during the testing
- No hydroalcoholic gel was used inside during the testing
- No outdoor air supply (closed APR gates 100%) was provided
- Filters were removed in the returns

(*) "unclean"- The trams prior to testing were in typical use, meaning with passengers in street dress and their usual personal hygiene (perfumes, deodorants, creams, etc.) and they made frequent stops, with doors opening and closing. When the trams arrived at the workshop/ testing area, they were not cleaned or ventilated.

The first sample was taken before the Plasma Air (PA604) bipolar ionization technology was deployed (control samples). The readings were taken every 15 minutes – over a two-day period:

- Swept VOCs of 54 compounds (see full report for all compounds)
- 7 Aldehydes - (Acetaldehyde, Acrolein, Benzaldehyde, Formaldehyde, Glutaraldehyde, Propionaldehyde, Crotonaldehyde)
- PM 2.5, PM 10 (particle count in 4 particle sizes– 0.3, 0.5, 1 and 5 microns)
- O₃ - Ozone, CH₂O - Formaldehyde, NO₂ - Nitrogen Dioxide

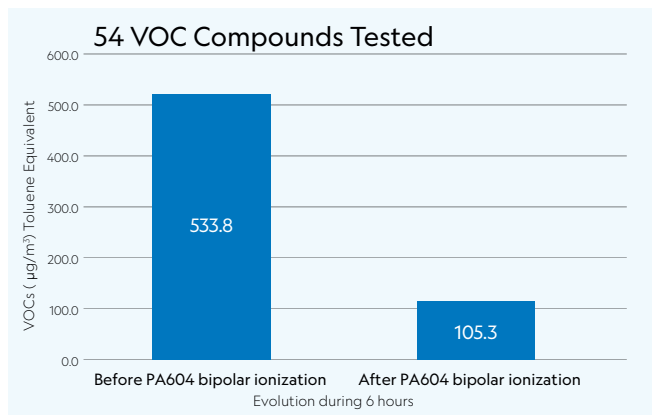
NOTE: Standard UNE 171330-2:2014, Indoor Environmental Quality and Part 2: Indoor Environmental Quality Inspection Procedures were in place.



PA604

RESULTS and CONCLUSION

VOCs concentration of 54 target compounds swept



80% reduction of the VOCs concentration (*)

in contrast by pump active sampling and chromatographic analysis of 54 target compounds [+ 6 hours of Plasma Air (PA604) bipolar ionizer(s) in operation].

(*) The concentrations of all VOCs detected (from the 54 series) are well below their threshold limit values (TLV) [Valores Límite Ambientales (VLA)] established by Instituto Nacional de Seguridad y Salud en el Trabajo (INSST) [Spain's National Institute for Occupational Health and Safety].

Particle Concentrate in the Air

The decrease in particle number of different micron ratings is relevant [2.5 hours of Plasma Air (PA604) bipolar ionizer(s) in operation].

The reduction of particles of 0.3 µ, 0.5 µ, 1 µ and 5 µ concentrations:

- 0.3 microns – 73%
- 0.5 microns – 88%
- 1 micron – 86%
- 5 microns – 75%

Ozone, Nitrogen Dioxide and 7 Aldehydes

Active sampling, through support capture, of the tested Plasma Air (PA604) bipolar ionizer(s), provides the following conclusions:

- There was **no detectable** generation (sample below the quantification limit) of Ozone by the operation of the PA604 bipolar ionizers.
- There was **no detectable** generation (sample below the quantification limit) of Nitrogen Dioxide by the operation of the PA604 bipolar ionizers.
- There was **no detectable** generation (sample below the quantification limit) of Acetaldehyde, Acrolein, Benzaldehyde, Crotonaldehyde, Formaldehyde, Glutaraldehyde, or Propionaldehyde by the operation of the PA602 bipolar ionizers.

NOTE: This test was commissioned to MONSOLAR by TAYRA S.L. a Plasma Air Distributor under the leadership of the Project Director, Paul Gerard O' Donohoe.