PRINTER EMISSION MEASUREMENTS AT TSI

APPLICATION NOTE PER-001

Health Risk from Laser Printer Emissions

A recently published study in Australia [1] found that tiny particles released from some home and office laser printers are as dangerous to human health as inhaling cigarette smoke. Researchers found that nearly one-third of the 62 printers they tested emitted high levels of the ultrafine toner particles (diameter <100 nm). Several other evaluations by researchers in different parts of the world echo similar concerns [2-6]. Common office products, including printers, copiers and other electronic devices, can release gases and ultrafine particles into the indoor air. Such contaminants are easily inhaled into the smallest passageways of the lungs where they could pose a health concern. Symptoms such as asthma and pseudo allergic inflammations of the respiratory tracts, irritations of the skin and eyes, and headache and sick building syndrome have been linked to these emissions [7]. Particulate emissions from office machines must be characterized in order to establish a database for the evaluation of possible health risks and prevention measures.

Printer Emission Measurements at TSI

Objective

The purpose of this study was to measure number concentration and size distribution of particulate emissions from a laser printer using TSI particle counting and sizing instruments.

Methods

Instruments Deployed

- TSI Model 3775 Condensation Particle Counter (CPC) for number concentration measurements.
- TSI Model 3936L85 Scanning Mobility Particle Sizer™ (SMPS™) spectrometer for particle size distributions.
- TSI Model 3321 Aerodynamic Particle Sizer® (APS) spectrometer for supermicrometer (diameter >1 μm) particle measurements.

Printer Used

- Leading brand laser printer (black & white copy only).

Figure 1: Phone booth office showing laser printer and measuring instruments

Experimental Setup

A small phone booth office at TSI Incorporated (Shoreview, MN) was used as a crude “chamber” (figure 1). The measurement instruments and the printer were placed inside the office with ventilation air vents closed. Conducting tubes were connected to instrument inlet ports to enable sampling right off the printer exhaust vent. The office door was closed after the print command was issued.

Results and Discussion

Data was collected over a 20 minute period. In order to measure the background particle concentrations, measurements were started before the print command was issued. A total of 80 pages were printed over a 2 minute period (16:23–16:25 hrs), during which particle counts elevated from a background concentration of 1,500 particles/cm^3 to a maximum at 570,000 particles/cm^3 (figure 2). The particle concentrations elevated soon after the printing started without any lag. Once the printing stopped, the airborne particle count decayed very slowly. Measurements after a 10 minute decay period showed high particle concentrations (>100,000 particles/cm^3) still persisted in the office. If left undisturbed, it would have taken hours for the concentrations to return back to background levels. The office door was opened at 16:35 hrs. Particle concentrations decayed quickly to background concentrations owing to rapid mixing of particles with surrounding air.

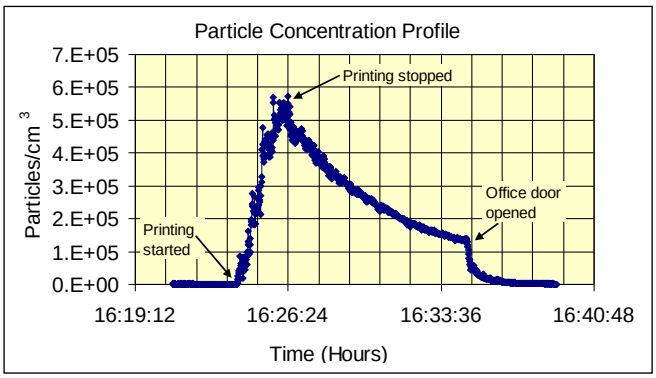

Figure 2: Temporal changes in particle concentrations inside the test office measured with TSI Model 3775 CPC

Particle size distributions were measured using a TSI Scanning Mobility Particle Sizer™ spectrometer. Figure 3 shows evolution of particle size distributions during the printer testing. An additional log-log scale plot of the same data is shown to facilitate comparison of background distributions (very low concentrations) with printer emissions (two orders of magnitude higher concentrations). As can be seen from these plots, the background size distributions measured at 16:20 and 16:36 hrs are polydispersed consisting of a mixture of different particle sizes. Moreover, the background size distributions are uni-modal consisting of one broad peak. Size distributions measured after printing started (see curves at 16:24 to 16:33 hrs) show a surge in mostly ultrafine particles with more than 90% of the particles emitted being smaller than 50 nm in diameter. This establishes that the particles contributed by the printer are extremely tiny. The size distributions of the emitted particles are bimodal; with a predominant peak at 20-25 nm and a secondary peak at around 70 nm (this can be seen more clearly as a shoulder in the log-log scale plot). These observations suggest newly formed particles from semi-volatile precursors released possibly from heating of toner particles. The rapid cooling and dilution of printer exhaust will facilitate condensation of volatile organic compounds (VOCs) to nucleate and form tiny particles. The second mode at approximately 70 nm suggests a secondary source or formation mechanism within the printer. As toner powder particles usually have diameters above 3 µm the observed particles cannot be attributed to toner powder resuspension. Separate measurements made with an Aerodynamic Particle Sizer® spectrometer confirmed absence of supermicrometer particles (diameter > 1 µm) from the printer emissions.

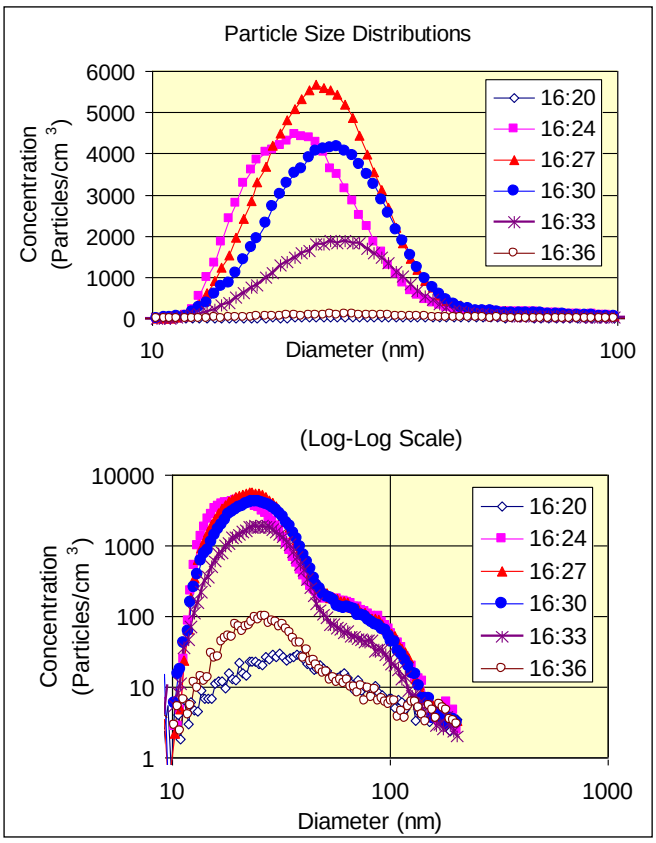

Figure 3: Evolution of particle size distributions measured inside the test office before, during, and after the printing operation (see time stamps)

The measurement and analysis of particle size distributions in printer emissions provides insights into probable formation mechanisms and sources, and can aid printer manufacturers in the design of printers to minimize emissions of particles. Additionally, particle size is critical in understanding the underlying health effects. The tiny ultrafine particles can deposit in the innermost regions of the lung with a potential for causing more damage than the larger coarse particles that usually deposit in the upper airways and are purged out of the body comparatively easily.

Summary

Recent research suggests that office devices like photocopiers, laser printers and multifunctional devices are often a significant source of ultrafine particles. These tiny particles are associated with adverse health impacts. We measured ultrafine particle emissions from a leading brand laser printer using TSI particle counting and sizing instruments. Our results show that if the test laser printer is placed in a relatively small office with poor ventilation, alarming levels of particulates can build up and persist. The emitted particles measured in this study were extremely tiny, mostly smaller than 50 nm in diameter.

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