



## Project Summary

# Office Equipment: Design, Indoor Air Emissions, and Pollution Prevention Opportunities

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The full report summarizes available information on office equipment design; indoor air emissions of organics, ozone, and particulates from office equipment; and pollution prevention approaches for reducing these emissions. Since much of the existing emissions data from office equipment are proprietary and not available in the general literature, they are not included in the report. The report covers (1) dry and wet process photoimaging machines (copiers, printers, and faxes); (2) spirit duplicators; (3) mimeograph machines; (4) digital duplicators; (5) diazo (blueprint) machines; (6) computers and computer terminals; (7) impact matrix printers; and (8) other equipment types.

Office equipment emits indoor air pollutants as a result of equipment operation, offgassing from components, or episodic releases related to catastrophic failure of a unit. For equipment that does not use supplies (e.g., video display terminals) emissions are primarily from offgassing of residual organics. Increased levels of ozone, total volatile organic compounds, and particulates have been observed in the presence of operating equipment and have been associated with complaints by exposed workers. Published emission rates, IAQ impacts, and potential pollution prevention solutions associated with the equipment types are discussed in the full report.

*This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully*

*documented in a separate report of the same title (see Project Report ordering information at back).*

### Background

Several recent studies by the U.S. Environmental Protection Agency (EPA) have identified indoor air quality (IAQ) as one of the most important environmental risks to the Nation's health. People spend approximately 90% of their time in indoor environments such as residences, public buildings, and offices, where concentrations of many pollutants are frequently higher than in outdoor urban air. Some activities can lead to indoor air pollutant levels up to 1,000 times higher than outdoor levels.

Approaches for improving IAQ to date have generally focused on mitigation techniques such as ventilation and air cleaning. These traditional mitigation approaches do not prevent pollution—the pollution is simply transferred to another medium or outdoors. Depending on the source of indoor air pollution, another approach is to focus on source reduction, ensuring that pollutants do not enter the indoor environment in the first place. In the Pollution Prevention Act of 1990, Congress declared that pollution should be prevented or reduced at the source whenever feasible. Source reduction may be accomplished by modifications to equipment, processes, and procedures; reformulations or redesign of products; substitution of raw materials; and improvements in use procedures. In multimedia pollution prevention, all environmental media are considered, and transfer of risks or pollution from one medium to another is avoided.

EPA's Air and Energy Engineering Research Laboratory (AEERL) is responsible for EPA's indoor air engineering research. AEERL's Indoor Air Branch (IAB) is integrating IAQ and pollution prevention into a strategic approach to indoor air source management. IAB's pollution prevention/IAQ research objective is to employ accepted pollution prevention techniques to reduce indoor air pollution through the development of low-emitting materials (LEMs) and/or low-impact materials (LIMs). LEMs are used in the same manner in the same indoor environment as another material but emit less pollution. LIMs are designed to be more amenable to control (e.g., ventilation) than a similar material used in the same manner in the same indoor environment.

## **EPA Research on Office Equipment**

In October 1993, Research Triangle Institute (RTI), Underwriters Laboratories (UL), and AEERL's IAB initiated a cooperative agreement to research pollution prevention approaches for reducing indoor air emissions from office equipment. The objectives are to characterize indoor air emissions from selected types of office equipment, then to identify and evaluate pollution prevention approaches (i.e., the development of LEMs/LIMs). The research approach includes literature reviews of emissions from office equipment; development of a standard test method; emission testing and modeling of selected equipment; and cooperative interaction with industry to identify, evaluate, and implement research, development, and demonstration activities to reduce the indoor air impact from office equipment. Technical advisors have been organized by IAB and RTI to provide expertise for the project. The advisors include trade association representatives, industry representatives, and academia.

The objective of the report is to summarize available information on office equipment design; indoor air emissions of organics, ozone, and particulates from office equipment; and pollution prevention approaches for reducing these emissions. Note that much of the existing emissions data from office equipment are proprietary and not available in the general literature and are therefore not included in the report. The full report covers the following types of equipment:

- Dry and wet process photoimaging machines (copiers, printers, and faxes)
- Spirit duplicators
- Mimeograph machines

- Digital duplicators
- Diazo (blueprint) machines
- Computers and computer terminals
- Impact matrix printers
- Other equipment types

The full report emphasizes photoimaging machines because of their prevalence, their projected growth in sales, and potential opportunities for pollution prevention. Equipment such as very large, high-volume duplicating machines and offset printing presses that are commonly used at quick-print shops are not included in the report. Office products such as adhesives, correction fluids, pens/markers, and carbonless copy paper may contain chemicals that impact IAQ. However, office products are not being researched under this project. In addition, the evaluation of electromagnetic fields that may result from the operation of some types of office equipment is outside the scope of this research.

## **Literature Summary**

The office environment contains many types of equipment that emit indoor air pollutants. Emissions may occur as a result of equipment operation, offgassing from components, or episodic releases related to catastrophic failure of a unit. For equipment that does not use supplies (e.g., video display terminals) emissions are primarily from offgassing of residual organics. The source of these organics can be either the construction materials (e.g., plastics casings) or components (e.g., cards used in manufacturing integrated circuit boards). Emissions resulting from offgassing decrease with time until they reach a point where they are negligible. It has been reported that over 300 hours of "on time" is required before video display terminal emissions reach a negligible level.

Emissions from equipment that uses supplies such as toner, ink, and paper (e.g., photocopiers, printers, diazo machines) result from both offgassing and operation. Emissions from offgassing will decrease with time; however, emissions from operation will either remain fairly constant or may even increase between routine maintenance and as the equipment ages. For example, ozone emissions from five tested photocopiers ranged from 16 to 131  $\mu\text{g}/\text{copy}$  before routine maintenance and were reduced to less than 1 to 4  $\mu\text{g}/\text{copy}$  after maintenance.

In general, published data on emissions from office equipment are limited. However, increased levels of ozone, total volatile organic compounds (TVOCs), and particulates have been observed in the presence of operating equipment. Increased

levels of ozone, formaldehyde, TVOCs, and particulates have been observed in a chamber evaluation of operating office equipment (three personal computers, one photocopier, and one laser printer). Thirty human subjects participating in the experiment had a significantly increased perception of headache, mucous membrane irritation, and dryness in the eyes, nose, and throat as well as reported dry and tight facial skin when exposed to the operating equipment in the chamber. Other researchers have also reported that emissions associated with normal operation of office equipment can contribute to increased indoor air pollutant concentrations and have been associated with complaints from exposed workers.

When evaluating the impact of a piece of office equipment on IAQ it is important to consider

- emission rates and duration,
- toxicity or irritation potential of substances emitted,
- physical relationships of the source, the occupants, and the space they occupy (the proximity of the source to people breathing its emissions can greatly affect the amount of dispersion and dilution of emissions and, therefore, the concentration actually breathed), and
- sensitivity of the occupants.

Table 1 summarizes published emission rates, IAQ impacts, and potential pollution prevention solutions associated with the equipment types discussed in the report. The equipment is listed in priority order (highest priority on top) for evaluation as part of the EPA and RTI pollution prevention research. The criteria used to prioritize the equipment types that are intended to maximize pollution prevention rewards include relatively high emissions (either as a unit or in total emissions), minimal design differences among manufacturers, easily understood processes, and the feasibility (both technical and economic) for pollution prevention measures and projected market share. For example, certain types of equipment with limited applications can have high emission rates but may affect IAQ in only a limited area or in a few locations (e.g., diazo machines). Others may have significantly lower emission rates on a per unit basis but may be found throughout a building and therefore have a significant overall impact on IAQ (e.g., printers).

Dry-process photocopiers have been identified as a high priority for pollution prevention research. They are prevalent in most office environments and are a

**Table 1.** Summary of Office Equipment Emission Information (Based on 1994 Literature Survey)

Type of Equipment	Emissions	IAQ/Emission Rate	Potential Pollution Prevention Solutions	General Comments on Pollution Prevention Research Selection Criteria
Dry-process photocopying machines	Hydrocarbons, respirable suspended particulates (toner powder), and ozone	O <sub>3</sub> : Average 40 µg/copy; peak production 131 µg/copy; 0-1350 µg/min, ave = 259 µg/min; 48-158 µg/copy; <4-54 µg/copy  Particulate: 0.001 µg/m <sup>3</sup> room concentration of black carbon. 90-460 µg/m <sup>3</sup> in exhaust air  TVOC: 0.5-16.4 µg/sheet from paper	Lower voltage to reduce ozone (charged rollers), toner reformulation, improved transfer efficiency, low maintenance machines, lower fuser temperature, changes in toner particle size, low-emitting components	Common product found in most office settings. Smaller units lower emission rates but more common, large production units often with dedicated HVAC systems, over 1.5 million units sold annually
Laser printers	Hydrocarbons, respirable particulates and ozone	O <sub>3</sub> : 100-4000 µg/m <sup>3</sup> room concentration; average 438 µg/min; 100 µg/min (w/filter)  Particulate: 60 µg/min  TVOC: 2.0-6.5 µg/sheet from paper	Same as for dry-process photocopying machines	Common technology found in most office settings
Computer terminals	Ozone and offgassing VOCs	Limited published data, TVOC: Maximum of 175 µg/hour from VDT drops quickly within 300 hours of on time	Low-emitting materials and/or lower voltage, alternative materials for cards used in integrated circuit boards	Thought to have relatively low emissions when compared to other sources that use supplies. Over 10 million units sold annually
Wet-process photocopying machines	Aliphatic hydrocarbons and ozone	TVOC: 25 g/h, 0.241 g/copy observed high room concentration of 64 mg/m <sup>3</sup> 4,150 mg/m <sup>3</sup> in exhaust air	Solvent reformulation; pressure fusing; decrease voltage, low-emitting components	Small market share
Ink/bubble jet printers	Hydrocarbons, ozone	No published emission rate or IAQ data	Solvent reformulation, low-emitting components	Used primarily for personal printers, home use
Spirit duplicators	Methanol	Breathing zone concentrations of 40-635 ppm; 195-3,000 ppm with no ventilation, 80-1,300 ppm with ventilation, and 9-135 ppm with enclosure and ventilation	Mineral spirits or replacement with photocopiers (may or may not be pollution prevention)	Limited market, schools and institutions
Mimeograph machines	Hydrotreated heavy and light naphthenic distillates	Heavy naphthenic distillate: 30 mg/page 10 mg/page light naphthenic distillate	Ink reformulation, replacement with photocopiers or other technologies (may or may not be pollution prevention)	Limited market, schools and institutions
Fax machines	Ozone and VOCs	No published emissions rate or IAQ data	Same as for dry-process photocopying machines	Found in most office settings, rapidly changing technology may be integrated with copier/printers
Digital duplicators	VOCs-petroleum solvent and ethylene glycol	Combined VOCs: 20 mg/page	Lower VOC inks, replacement with photocopiers (may or may not be pollution prevention)	Limited market share
Blueprint machines (dyeline)	Ammonia, carbon monoxide, methanol, ethanol, trinitrofluorene, trichloroethane	1-40 ppm ammonia in breathing zone of operator, average = 8.2 ppm	CAD/alternative technologies, improved maintenance	Older technology, losing market share to CAD/alternative technologies

(continued)

**Table 1. Continued**

<i>Type of Equipment</i>	<i>Emissions</i>	<i>IAQ/Emission Rate</i>	<i>Potential Pollution Prevention Solutions</i>	<i>General Comments on Pollution Prevention Research Selection Criteria</i>
<i>Impact printers</i>	<i>VOCs</i>	<i>TVOC: 0.7-1.0 µg/sheet from paper No data on emissions from operation</i>	<i>Low-emitting components reformulated inks</i>	<i>Used generally for personal printers, home use. Relatively low emission rates.</i>
<i>Plotters</i>	<i>VOCs</i>	<i>No published emission rate or IAQ data</i>	<i>Low-emitting components, reformulated inks</i>	<i>Limited market share, sales around 250,000 a year worldwide</i>

known source of ozone, particulate, and VOC emissions. The size of photocopiers can range from small personal models to fairly large machines that can have relatively high emission rates.

Laser printers, which use a technology similar to that of dry-process photocopiers and have been shown to have similar emissions, were identified as a secondary priority for pollution prevention research, given that they are much smaller in terms of throughput and concomitant unit emission rates than photocopiers and that NIOSH is conducting emissions tests on laser printers. NIOSH's testing program is intended to define emission rates for laser printers and will be used for estimating adequate ventilation needs. However, the results from the NIOSH study are expected to be shared with EPA and RTI and can

be used to support this pollution prevention research.

Indoor air emissions from computers and impact printers are limited to offgassing from basic construction materials and electronic components. These emissions are highest for new machines and diminish with time. Therefore, although they may impact localized IAQ and are found in most office settings, their total combined impact on IAQ is likely to be less than for dry-process photocopiers.

Wet-process photocopiers have been shown to be a major contributor to indoor air VOC levels in several studies and have significantly greater emissions than dry-process machines on a per unit basis. However, wet-process machines constitute a small part of the photocopier market. Therefore, although wet-process ma-

chines have higher per unit emission rates, dry-process photocopiers may result in greater overall emissions based on the greater number of units in operation.

Other equipment that has been shown to have high individual emission rates includes spirit duplicators, mimeograph machines, plotters, and diazo (blueprint) machines. However, this equipment is rather specialized, with limited numbers of units in operation. Furthermore, some of this equipment is no longer manufactured or is decreasing in use.

A final report covering the research conducted under this cooperative agreement between EPA, RTI, and UL will be issued upon completion of the research in 1996. Additional information on indoor air emissions from office equipment is available from the sources listed in Appendix A of the full report.

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**Kelly W. Leovic** is the EPA Project Officer (see below).

*The complete report, entitled "Office Equipment: Design, Indoor Air Emissions, and Pollution Prevention Opportunities," (Order No. PB95-191375; Cost: \$19.50, subject to change) will be available only from:*

*National Technical Information Service*

*5285 Port Royal Road*

*Springfield, VA 22161*

*Telephone: 703-487-4650*

*The EPA Project Officer can be contacted at:*

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