



The Office  
Equipment  
Industry's  
Guide to  
Managing  
Product  
Emissions



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## INTRODUCTION

Office equipment has contributed greatly to our capabilities, businesses, and productivity over the last several decades. These tools are essential to the modern office; however, advancements in technology and the use of chemicals in the manufacturing and operation of these machines have resulted in health consequences and new environmental concerns.

People are spending more time indoors than ever. Clearly, the importance of good indoor air quality (IAQ) is paramount. In fact, the U.S. Environmental Protection Agency (EPA) and other public health organizations have identified indoor air quality as one of the most important environmental risks to the nation's health. The U.S. Department of Labor Occupational Safety and Health Administration (OSHA) estimates that some 21.2 million Americans are working in 1.4 million buildings with indoor air pollution.<sup>1</sup>

Office machines including copy machines, laser and inkjet printers, computers, fax machines, scanners, and multi function peripherals (MFPs) contribute to indoor air pollutants that can negatively impact human health. While most manufactured products emit volatile organic compounds (VOCs) into the indoor air due to off gassing of components and construction materials, office machines contribute additional pollutants during operation.

Many office equipment manufacturers have recognized the potential hazards their equipment poses to indoor environments and are taking steps to build safer products. Others do not yet understand the importance of IAQ issues but will soon be faced with customers demanding low emitting office equipment, legislation forcing them to face the issues, and potentially costly litigation, if they fail to act.

This report provides complete information about indoor air quality issues related to office equipment manufacturers. ***In Black and White*** is designed to answer questions such as:

- What kinds of pollutants do office machines emit?
- Why should I test my product's emissions?
- How is testing conducted?
- Is there any legislation surrounding product emissions?
- What are the health implications of office equipment emissions?
- What are my testing options?
- Where can I find more information?

Office machine manufacturers need to know the problems, trends, significance, and their options for addressing problems. The information contained in the following pages provides a strong foundation for understanding the issues.

## **TRENDS**

Indoor air quality has been identified as one of the major environmental issues worldwide. The EPA's Indoor Environment Management Branch conducted a landmark study on office equipment emissions, "Office Equipment: Design, Indoor Air Emissions, and Pollution Prevention Opportunities." The report examines different types of office equipment and their contributions to indoor air pollution. Since the initial release of that report, other national and international public health and government agencies have conducted additional studies on the impact of office equipment on indoor air. As information on the topic becomes more available, so does the demand for action from office equipment manufacturers. The World Health Organization, American Lung Association, Work Safe Western Australia, the National Institute of Occupational Safety & Health, and the International Centre for Indoor Environment and Energy are just a few of the many organizations that are working to educate the public about indoor air quality issues. The following trends in indoor air quality and in the office equipment industry are driving office machine manufacturers to proactively manage their products' emissions.

### ***Demand for low emitting products***

As indoor air quality issues continue to be publicized through the general media, consumers and businesses alike are increasingly demanding low emitting products that contribute minimally to indoor air pollution. Many market segments purchase exclusively low emitting products as a part of their participation in programs such as the U.S. Green Building Council's Leadership in Energy & Environmental Design (LEED), and state/federal procurement requirements or simply to create healthier indoor environments. Office equipment manufacturers that do not adequately address product emissions issues will be excluded from large and growing markets for IAQ-friendly products.

### ***New regulations***

While there is currently no federal legislation surrounding limits for product emissions levels, some states have developed their own legislation to regulate product manufacturers. For example, the State of California enacted Proposition 65, a program that outlines harmful chemicals and requires manufacturers to determine whether or not their products contain any of these chemicals and to label products accordingly. Manufacturers bear the burden of proof, and failure to properly label materials could result in litigation.

### ***Litigation on the rise***

Litigation surrounding indoor air quality is on the rise. In a recent national survey, 24 percent of U.S. workers indicated that they believed they experienced indoor air quality problems in the work place.<sup>2</sup> Legal activity surrounding indoor air problems includes claims alleging harm from exposure to indoor air pollutants as well as disputes over the extent to which insurance covers these issues.<sup>3</sup> The increasing amount of data connecting product emissions with health problems will increase the frequency of litigation. Many manufacturers are enacting emissions testing as a measure to prevent costly litigation.

### ***Voluntary programs***

The EPA, the National Institute for Occupational Safety & Health (NIOSH), the US Consumer Product Safety Commission (CPSC), and the World Health Organization (WHO) are just a few of the organizations requesting voluntary pollution reduction measures. These organizations are studying the harmful agents, evaluating use complaints, and are likely to be the proponents of legislation in the future. Voluntary control programs including the Blue Angel Program and the GREENGUARD Certification Program, allow manufacturers to self-certify using standards established by qualified third party institutions and by testing in independent laboratories.

### ***Differentiation***

Many manufacturers are using environmentally friendly products as a way to differentiate themselves in the marketplace. Environmentally sound products generate trust and good will among customers. As office equipment products move toward a commodity market, marketers will continue to see the “greening” of their products as a way to stand out in the crowd.

## OFFICE MACHINE EMISSIONS

Office machines are like every other manufactured product in that VOCs off gas from components and construction materials. However, office machines also emit additional pollutants during operation. In addition to VOCs, ozone and respirable particles may be emitted continuously or episodically during operation (for example, during component failures or poor operation).<sup>4</sup>

Table I includes many VOCs commonly emitted from different kinds of office machines. Common sources include electronic components and adhesives, electronic and heating processes, inks and toners, papers and transparencies, plastics, flame-retardants, and cleaning solvents.

**Table I: VOCs commonly emitted from office equipment<sup>5</sup>**

<i><b>Laser Printers</b></i>	<i><b>Photocopiers</b></i>	<i><b>Computers</b></i>
<ul style="list-style-type: none"> <li>• 1-Butanol</li> <li>• Acetone</li> <li>• Ethylbenzene</li> <li>• Formaldehyde</li> <li>• Hexanal</li> <li>• Methylpropylnonane</li> <li>• Octamethyl-Cyclotetrasiloxane</li> <li>• Pentamethylheptane</li> <li>• Styrene</li> <li>• Xylenes</li> </ul>	<ul style="list-style-type: none"> <li>• Acetaldehyde</li> <li>• Acetone</li> <li>• Benzaldehyde</li> <li>• Ethylbenzene</li> <li>• Formaldehyde</li> <li>• Hexane</li> <li>• Nonanal</li> <li>• Octanal</li> <li>• Styrene</li> <li>• Xylenes</li> </ul>	<ul style="list-style-type: none"> <li>• 1-Phenylethanone</li> <li>• 2-Ethyl-1-hexanol</li> <li>• Ethylbenzene</li> <li>• Ethylhexylpropenoic ester</li> <li>• Hexamethyl-cyclotrisiloxane</li> <li>• Methylacrylate</li> <li>• Phenol</li> <li>• Trichloroethane</li> <li>• Toluene</li> <li>• Xylenes</li> </ul>

Specific VOCs from office machines include aromatics and siloxanes,<sup>6</sup> which are emitted by computer circuit boards, monitors, and printer toner, and esters and acrylates, which may be used as coalescing agents or as monomers in polymer-based products.<sup>7</sup> Particles may become airborne through aerosolization, a process used by copiers and printers to transfer toner to the printed page. Ozone may be generated from office machines through the use of electric charging devices during the processes of copying and printing. Phthalates may be released from resins in circuit board and component materials.

Carbon black can also be released from toners, which are generally a mixture of plastic resin, carbon black, and other additives.<sup>8</sup> Carbon black consists of particles and impurities that are of respirable size.

The International Centre for Indoor Environment and Energy conducted a study on electronic equipment, including computer monitors. The group conducted sensory evaluations of offices with computers. The results showed that the air quality was significantly poorer in the offices in which computers with monitors were placed compared with empty offices.<sup>9</sup> Pollutants and odors are released when normal operations heat the unit, promoting the release of odorous compounds, plastic additives, and flame-retardants used in the plastic in the screen.<sup>10</sup>

## HEALTH IMPLICATIONS

While scientists and medical professionals have not yet discovered the full extent of negative health effects caused by poor indoor air quality, research has demonstrated that a number of symptoms and respiratory problems have been associated with poor indoor air. In an EPA study, thirty human subjects 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.<sup>11</sup>

The release of organic chemicals may also result in irritating odors, found unacceptable by building occupants. These odors may lead to headache, upper respiratory irritation, and nausea. Odors also provide a "fear of the unknown" among occupants, which leads to anxiety. The release of VOCs is often characterized by an array of symptoms that correspond with "sick building syndrome" including headache, nausea, general malaise, eye, nose, throat and skin irritation.

Carbon black has long been considered a nuisance, but has been found to contain carcinogenic impurities. Health effects associated with carbon black include irritated eyes, headache, and itching skin. It has also been linked with small growths on the tongue when touched by hands contaminated with carbon black. (For example, when wetting a finger to sort through copied papers.)<sup>12</sup>

The London Hazards Centre publishes a "Photocopier and Laser Printer Hazards" fact sheet that outlines the health impacts of many of the different compounds and pollutants released by office machines, primarily photocopiers and laser printers. The table below summarizes the health consequences according to that document:

**Table II: Health Effects<sup>13</sup>**

ozone	Eye, nose, throat, lung irritation, dermatitis, headache, nausea, premature ageing, potential reproductive dangers
111-trichloroethane	Skin irritation
toluene	Fatigue, drowsiness, throat and eye irritation
benzene	Carcinogen
xylene	Kidney failure and menstrual disorder
selenium and cadmium sulphide	Throat irritation, (high levels ) vomiting, nausea, skin rashes, rhinitis
nitrogen oxide/ carbon monoxide	Headache, drowsiness, faintness, increased pulse rate
toner (carbon black)	Irritated eyes, headache, itching skin

Even more shocking, Office Solutions reports that the National Cancer Institute estimates that up to 98% of all cancers may be linked to chemical exposure. More than 37 million people in the United States are believed to have an increased sensitivity to chemicals.<sup>14</sup> Also alarming is the escalation of asthma with over 17.3 millions Americans affected, according to the Centers for Disease Control.<sup>15</sup>

While medical research is neither complete nor conclusive at this time, evidence clearly indicates that indoor air pollutants can trigger health concerns among occupants.

## TESTING PROTOCOL

At Air Quality Sciences, we have one of the most advanced environmental chamber laboratories in the world. The information below describes the testing methods used in our laboratory, which are based on globally accepted environmental chamber testing technology, as presented in ASTM Standard D6670-01. The AQS methodology has been adopted by the GREENGUARD Environmental Institute as its standard test method for measuring emissions from equipment.

In 1998, as a follow-up to the original study on office equipment (which was released in 1995), the EPA released another study, "Indoor Air Emissions from Office Equipment: Test Method Development and Pollution Prevention Opportunities," outlining a large chamber test method for testing office equipment. This task presented many challenges for the investigative team including heat generated from the operating equipment, finite paper supplies, power requirements to the machinery, and remote operation of the equipment. The test protocols used by AQS were established specifically for office equipment based on that standard. In fact, AQS assisted the EPA in developing and validating the test methods.

### ***How testing is done***

Testing is conducted in a large, stainless steel environmental chamber, greater than 5m<sup>3</sup> in volume, which is designed to simulate environmental conditions within a room. Environmental conditions including temperature, relative humidity, and ventilation are controlled using precisely calibrated equipment. Highly purified supply air is delivered to the chamber at rates equivalent to a typical office environment. During operation of the office machine in the chamber, emissions of VOCs, ozone, and particles are measured down to the parts-per-trillion (ppt) level.

Several measurements are required prior to chamber evaluation. For photocopiers and printers, the rate at which the machine is capable of generating a test image is determined. This information is used along with the paper capacity of the machine to determine the maximum length of operation of the equipment during testing. This will allow determination of the measurement interval to achieve optimum accuracy and precision.

Electrical interfacing of office machines is also required prior to chamber testing. For both printers and photocopiers, the chamber is equipped with an electrical supply. For computer printers, an electrical interface between an external computer and the printer within the chamber is created, allowing remote operation of the printer.

Once all the preparations are made, air within the empty chamber is monitored for VOCs, particulates, ozone, and aldehydes. The office machine is then placed in the controlled chamber and the chamber air is tested as the machine is powered, but not operating. This data provides a baseline against which results collected during the machine's operation are calculated. The machine is then operated remotely and the air is monitored once again. Emissions are measured down to extremely low parts-per-trillion levels. Measured emissions rates are then used in mathematical models to estimate expected human exposure levels within a "real" setting. The following table, originally presented at Design for the Environment Symposium, presents emissions data obtained from five dry process photocopiers, twelve laser printers, and six personal computers.

**Table II: Summary of Emission Rate Data for Office Equipment**

**Average contaminant ER in mg/hr (range of values)**

<b>Equipment/Process</b>	<b>TVOC</b>	<b>Total Particles</b>	<b>Ozone</b>
Laser Printers	27.5 (2.4 - 100.2)	1.4 (<0.02 - 4.8)	0.5 (<0.02 - 4.2)
Dry Process Photocopiers	37.9 (15.0 - 91.2)	1.6 (<0.7 - 4.5)	4.3 (1.2 - 5.0)
Personal Computers	12.2 (0.05 - 24.2)	0.05 (<0.027 - 0.12)	<0.02

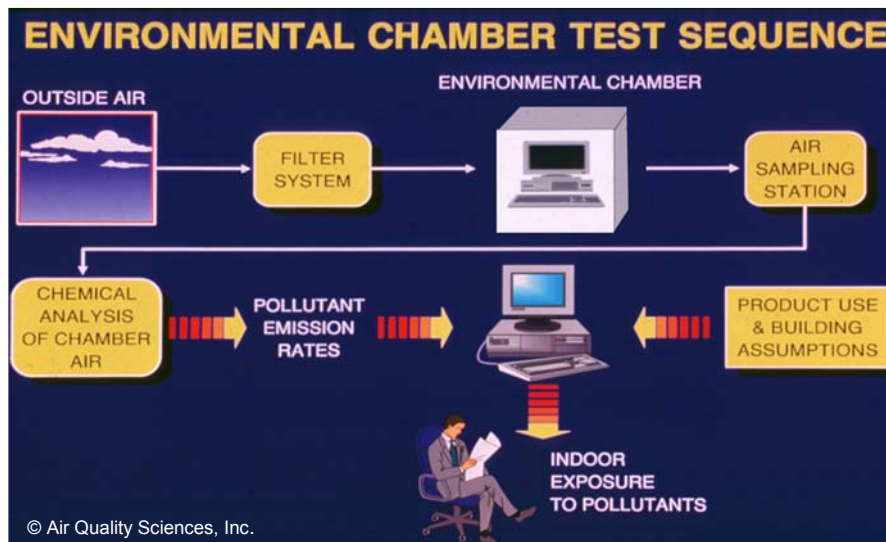
Emission rates are expressed as milligram (mg) of contaminant emitted per hour of equipment operation. Background emissions were measured from printers and photocopiers, which were energized, but not actively printing. TVOC background averaged 1.4 mg/hr, but there were no measurable background levels of ozone or particles. There was an increase in all pollutant measurements, including ozone and particles during operation.

**Results**

Test results are delivered to the manufacturer with complete quantitative data from the chamber test as well as a qualitative assessment of the results. The data provided allows manufacturers to:

- View a complete list of what is being emitted from the product in question
- Compare emissions data and exposure concentrations with specifications set by different agencies' prescribed emissions standards
- Provide for third party certification requirements
- Consider exposure rates and potential health consequences of a product's emissions
- Track pollutant emissions to their source within the machine
- Identify sources of unacceptable odors

Manufacturers' internal engineers may use this comprehensive information to understand the product's emissions and likely sources of pollutants. Alternatively, IAQ consultants can be engaged to analyze results and propose potential solutions.



## **TESTING OPTIONS**

There are several testing options available to manufacturers that want to manage their products' emissions. There are no regulated standards, and certification programs are currently voluntary, so managing product emissions is largely focused on corporate commitment to design products for today's indoor environmental quality needs and to protect the health of all users.

### ***Basic Protocol***

Following a standardized protocol, testing involves measuring emissions of equipment during both idle and operational modes. Emissions of ozone, respirable particles, aldehydes, and volatile organic compounds (VOCs) are generally measured and reported in emission rates, the amount of contaminant released per unit of time.

This is an excellent test for manufacturers during their product development process and for those who are just initiating product emissions testing. The basic test provides information about the types of emissions and their levels during normal operation of the equipment. Results provide a starting point for identifying potential problems and making adjustments. They also provide a standardized test platform for comparing emissions among different models of equipment, evaluating the impact of manufacturing changes aimed at reducing emissions, and evaluating "complaint" products from customers.

### ***Component Protocol***

There is often a need to identify the source of certain VOC emissions from the equipment. In this case, individual materials, components, and media are tested. These often include circuit boards, plastic resins, adhesives, solders, toners, paper, transparencies, and inks. A simple emissions test is conducted at room or heated temperatures. Specific chemicals identified will assist in identifying the sources of those being found in the operating equipment. This test can also be used to qualify the suppliers of materials and media.

### ***Odor Protocol***

Users may complain about unusual or unacceptable odors originating from operating equipment. This typically occurs with new equipment and goes away with time. In some cases, it is important to identify the odor so that user concerns can be addressed and corrective action taken. The equipment is tested under normal use applications, and measurements are made for aldehydes and VOCs, which are typical sources of odors. All chemicals identified are compared to AQS' extensive database of odorants to identify the culprit.

### ***Risk Assessment***

A risk assessment evaluates a product's potential to produce adverse human health effects. Emission data obtained from environmental chamber testing is used to predict human exposure concentrations of contaminants, and these concentrations are assessed for their potential to produce cancer and non-cancer risks. The data is reviewed according to standards and guidelines available from California's Proposition 65, OSHA's occupational exposure limits, Germany's MAK (Maximale

Arbeitsplatzkonzentration) occupational levels, the EPA's carcinogenic and non carcinogenic risk levels, and sensory irritation and odorant limits available from numerous scientific organizations. Risk assessment is a must for those manufacturers who want to understand potential health risks associated with use of their products.

### **Certification Protocol**

Manufacturers can apply to voluntary certification programs like the GREENGUARD Certification Program for low emitting products. These programs offer third party verification that a product exceeds basic low emitting standards as currently being required of numerous purchasing and green building programs. Testing can be done to prequalify products for the program, or official program testing can be completed for application submittals. Testing protocols are also available for pre-qualification for additional programs such as Germany's Blue Angel Emission requirements.

## ***Here's what some organizations are saying about office equipment and IAQ...***

"Emissions from equipment, such as computers, will decrease over time compared to emissions from equipment that continually uses chemicals. Emissions from such equipment (E.G., laser printers) that use chemicals continually, will obtain a steady state concentration dependent upon the chemicals used and frequency of equipment use." **Occupational Safety & Health Administration**, "Indoor Air Quality, Proposed Rules" 4/5/94. (59-15968-16039)

"Photocopiers and laser printers are safe when used occasionally and serviced regularly. But if they are badly positioned, poorly maintained and used frequently or for long runs, there are risks to health, ranging from irritated eyes, nose and throat to dermatitis, headaches, premature ageing and reproductive and cancer hazards." **The London Hazards Centre Factsheet**, "Photocopiers and Laser Printer Hazards" December 2002.

"A rule of thumb states that a pollutant released indoors is 1000 times more likely to reach people's lungs than a pollutant released outdoors." **World Health Organization Fact Sheet No. 187**. Revised, September 2000.

## **STANDARDS & GUIDELINES**

Currently, there is no federal law or regulation obligating manufacturers to monitor product emissions. However, some states and organizations have taken their own measures to implement emissions standards, at least where state-funded projects are concerned. The following are some of the states that have established a standard that manufacturers must meet to bid on government projects. In addition, international groups, particularly in Europe, are taking active steps to encourage manufacturers to manage their product's emissions. Below are some prominent examples of both voluntary and regulatory programs in the United States and abroad.

### ***California's Proposition 65***

Originally the Safe Drinking Water and Toxic Enforcement Act of 1986, Proposition 65 requires product manufacturers to provide warning to consumers if their products discharge or release chemical substances that may cause cancer or reproductive toxicity. Each year, California's Governor is required to produce a list of chemicals that are known carcinogens. Manufacturers that fail to comply with Proposition 65 may be subject to fines, litigation, and class action suits. Chemical content of a product does not reflect a product's emissions, since many chemical compounds are produced from the operation and use. Formaldehyde, acetaldehyde, and toluene are among the most common VOCs emitted from office equipment that are listed by Proposition 65.

### ***State of Washington***

The State of Washington has specifications for product emissions that can be released by products affecting indoor environmental quality. To bid on projects managed by the State of Washington, manufacturers must meet these standards. Emission standards exist for VOCs, formaldehyde, particles, ozone, carbon monoxide, and any pollutant controlled by the ambient air quality standards.

### ***Federal Agencies***

Although there are no federally mandated indoor air quality standards, the Environmental Protection Agency (EPA) has encouraged the development and control of emissions of office equipment, as well as other indoor products. EPA has published numerous reports on indoor pollution prevention strategies for office equipment and validated a test method for conducting measurements. Numerous agencies have developed low emission procurement guidelines. Meeting the guidelines is voluntary, but they are recommended and required to bid on some government projects.



### ***GREENGUARD Certification***

The GREENGUARD Environmental Institute is an independent, non-profit organization that oversees the GREENGUARD Certification Program, including the establishment of

acceptable standards for indoor products and testing protocols. Products meeting the low emitting emissions criteria, and that are monitored on an ongoing basis, can carry the GREENGUARD Certification mark. Standards are based on globally recommended limits for product emissions. GREENGUARD Certified or tested furniture and furnishings are part of the United States Green Building Council's LEED for Commercial Interiors Program. Emission requirements cover general VOCs, styrene, particles, formaldehyde and ozone.



### ***Blue Angel Program***

The Blue Angel Program was introduced in 1977 as the first "eco-labeling" program. Blue Angel is a completely voluntary program but has been widely accepted by manufacturers internationally, particularly in Europe. Blue Angel measures products on many environmental criteria, including product emissions. Thousands of Blue Angel labels have been awarded over the years, and demand for labeled products continues to grow. Many US manufacturers are already working to comply with the standards of this program. Blue Angel emissions criteria are available for styrene, particles, and ozone.

### ***World Health Organization***

The World Health Organization (WHO) has established guidelines for air quality designed to provide exposure levels below which no adverse human health effects are expected. The WHO states that these guidelines are designed to enable countries to set their own specific standards for indoor and outdoor air quality. Recommendations are available from WHO on pollutants such as ozone, styrene, formaldehyde, and respirable particles that are typically emitted from office equipment.

## FOR MORE INFORMATION

For additional information about Indoor Air Quality, please visit the following sources.

[www.aqs.com](http://www.aqs.com) - Air Quality Sciences' website

[www.lungusa.org](http://www.lungusa.org) - American Lung Association

[www.aerias.org](http://www.aerias.org) - Aerias - online resource for information on indoor air quality

[www.epa.gov/iaq/ia-intro.html](http://www.epa.gov/iaq/ia-intro.html) - EPA, an Introduction to Indoor Air Quality

[www.cdc.gov/niosh/homepage.html](http://www.cdc.gov/niosh/homepage.html) - NIOSH National Institute of Occupational Health & Safety

[www.greenguard.org](http://www.greenguard.org) - GREENGUARD Environmental Institute and the voluntary program to be certified as a low emitting product

[www.who.int/en/](http://www.who.int/en/) - World Health Organization

**or contact Air Quality Sciences at  
(770) 933-0638 or email us at [info@aq.com](mailto:info@aq.com).**

## END NOTES

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<sup>1</sup> U.S. Department of Labor, Occupational Safety & Health Administration, Federal Registers – 59:15968-16039, April 1994, <http://www.osha.gov> (16 May 2003).

<sup>2</sup> Kurt E. Blasé, J. Vance Hughes, and Thomas K. Bick, "More people are suing over indoor air problems." *Washington Business Journal*. April 12, 1999.

<sup>3</sup> Kurt E. Blasé, J. Vance Hughes, and Thomas K. Bick, "More people are suing over indoor air problems." *Washington Business Journal*. April 12, 1999.

<sup>4</sup> Environmental Protection Agency, "Office Equipment: Design, Indoor Air Emissions, and Pollution Prevention Opportunities," EPA/600/SR-95/054, June 1995, <<http://www.epa.gov>> (16 May 2003).

<sup>5</sup> Marilyn S. Black, "Emissions from Office Equipment," IS&T's International Conference on Printing Technologies, October, 1999.

<sup>6</sup> B.O. Brooks and W.F. Davis. *Understanding Indoor Air Quality*. Boca Raton, FL: CRC Press. 1992.

<sup>7</sup> P.W. Wolkoff, C.K. Wilkins, P.A. Clausen and K. Larsen, "Comparison of volatile organic compounds from office copiers and printers: methods, emissions rates, and modeled concentrations," *Indoor Air* 3, (1993): 113 – 123.

<sup>8</sup> London Hazards Centre, "Photocopiers and Laser Printer Hazards." December 2002, <<http://www.lhc.org.uk>> (16 May 2003).

<sup>9</sup> Pawel Wargocki, "New Studies on emissions from electronic equipment." *International Centre for Indoor Environment and Energy*. 11 September 2001, <<http://www.ie.dtu.dk>> (16 May 2003).

<sup>10</sup> Pawel Wargocki, "New Studies on emissions from electronic equipment." *International Centre for Indoor Environment and Energy*. 11 September 2001, <<http://www.ie.dtu.dk>> (16 May 2003).

<sup>11</sup> Environmental Protection Agency, "Office Equipment: Design, Indoor Air Emissions, and Pollution Prevention Opportunities," EPA/600/SR-95/054, June 1995, <<http://www.epa.gov>> (16 May 2003).

<sup>12</sup> London Hazards Centre, "Photocopiers and Laser Printer Hazards." December 2002, <<http://www.lhc.org.uk>> (16 May 2003).

<sup>13</sup> London Hazards Centre, "Photocopiers and Laser Printer Hazards." December 2002, <<http://www.lhc.org.uk>> (16 May 2003).

<sup>14</sup> Cullen, Scott: "Your office may be hazardous to your health." *OfficeSolutions*. November 1, 2002.

<sup>15</sup> Institute of Medicine, *Clearing the Air: Asthma and Indoor Air Exposures*. Washington, DC: National Academy Press. 2000.