Meeting Green:

The Office Equipment Industry's Guide to Managing Product Emissions

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As industrialized nations' economies have moved from manufacturing toward services that depend heavily on information technologies, electronic office equipment, such as copiers, tabletop printers (laser and inkjet), computers (desktop and notebooks), monitors, scanners and fax machines, have become not only ubiquitous in most offices, but also are commonly found in homes and schools. In the United States, for example, more than one-half of homes have at least one computer (Newberger 2001).

These machines, particularly computers, monitors and printers, are often located in close proximity to those working with them, which is very convenient and enhances worker productivity, but may also increase the risk of inhaling volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), ozone and particulate emissions from these products. Exposure to elevated levels of indoor contaminants may cause acute and chronic illnesses, including allergy and asthma attacks. While this is an important consideration for adults, the risk to children may be even greater as they are more susceptible to environmental pollutants.

In response to these concerns, manufacturers are proactively designing their products to minimize VOC, SVOC, ozone and particulate emissions. Several organizations in the US and Europe have established "eco-criteria" for acceptable levels of airborne contaminants emitted from printers and copiers. These international programs include Germany's Blue Angel Program, the GREENGUARD Certification Program, EcoLogo[M] Program (Canada) and the Electronic Environment Product Assessment Tool (EPEAT).

In addition, many market segments purchase exclusively low-emitting products as a part of their participation in programs such as the US Green Building Council's (USBGC) LEED Green Building Rating System™ and state and federal procurement programs. As a result, manufacturers are finding that creating products that meet specific eco criteria can be an important differentiator in the marketplace. Some manufacturers are going a step further and demonstrating compliance by earning third-party certifications from GREENGUARD, Blue Angel, EcoLogo or all three. Results from studies examining emissions from other types of electronic office equipment also are helping manufacturers create safer products.

This report serves as a manufacturer's user guide for understanding the types of indoor contaminants emitted from electronic office equipment and the health impacts associated with chemical and particulate emissions. It also reviews the available third party certification programs and their respective eco-criteria. In addition, the technology and testing protocols for measuring chemical and particulate emissions and for establishing the health risks associated with these emissions are discussed.

Marketplace Drivers

The US Environmental Protection Agency (USEPA) warned nearly 20 years ago in its report to Congress on indoor air quality (IAQ) that "indoor air pollution represents one of the most important environmental problems based on population risks" and that the "population health risks posed by exposure to indoor air pollutants appear to be significantly greater than the health risks posed by some of the environmental problems that receive the most public concern and governmental funding" (USEPA 1989). Since then, the USEPA also has warned that indoor air in the US is two to five times more polluted than outdoor air (USEPA 2001). Much of this increased risk can be attributed to the following:

- Higher levels of indoor pollutants as a result of buildings and homes being built tighter to conserve energy
- A stronger dependence on mechanical ventilation systems that often are inadequate for diluting and removing indoor pollutants
- More time spent indoors (as much as 90 percent)
- Greater use of synthetic materials that can emit VOCs in construction and building materials, furnishings and finishes, cleaning products and processes, office equipment, and consumer products

In response, the following market trends have emerged and have played a significant role in how manufacturers view risks associated with VOC, SVOC and particulate emissions and their efforts to ensure their products meet market demands and are safe.

Demand for low emitting products in green markets. As noted, consumers and businesses are increasingly demanding that manufacturers create low emitting products to minimize exposure to indoor air pollutants. Many market segments purchase exclusively low-emitting products as a part of their participation in programs such as the US Green Building Council's (USBGC) LEED Green Building Rating System™ and state and federal procurement programs. Office equipment manufacturers that do not adequately address product emissions issues risk being excluded from large and growing markets for environmentally friendly products.

Greater sophistication in the reporting and understanding of IAQ issues. In recent years, the news media have become more sophisticated in their reporting on IAQ issues. For example, a recent story on a University of Washington and Seattle Children's Hospital Research Institute study about the levels of phthalates in babies' urine received wide coverage. Researchers found that "babies [who had been] recently treated with infant personal care products were more likely to have manmade chemicals called phthalates in their urine than other babies. Phthalates…are many common household plastic and vinyl products, and some studies suggest they may affect reproductive development in humans" (Science Daily 2008). Phthalates, a type of SVOC, also are used to make plastic more flexible. As a result of more sophisticate news stories, consumers also are becoming more sophisticated in their understanding of some of the more prevalent indoor air pollutants and the risks to health associated with them.

Indoor air quality regulations. While there are presently no federal regulations that specifically address VOC, SVOC and particulate emission levels for products used indoors, some states have developed their own laws to regulate product manufacturers. For example, the State of California enacted Proposition 65, a program that lists harmful chemicals and requires manufacturers to determine whether or not their products contain any of these chemicals and to label their products accordingly. Manufacturers bear the burden of proof, and failure to properly label materials could result in being sued. Other voluntary programs such as LEED Green Building Rating System and the

Collaborative High Performance School Programs specify the use of low emitting products and equipment in homes, schools and buildings.

Litigation. Litigation surrounding indoor air quality is always a concern. A national survey of US office workers found that 24 percent believed they experienced IAQ problems in the work place. Legal action frequently includes claims alleging harm from exposure to indoor air pollutants as well as disputes over the extent to which insurance covers these issues (Blasé et al 1999). Many manufacturers are participating in product emissions testing as a way to prevent and defend against costly litigation.

Voluntary Programs. The USEPA, the National Institute for Occupational Safety and 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.

Among the many programs that address VOCs in products, only three – GREENGUARD, the EcoLogo Program and Blue Angel – actually certify office equipment products as low emitting. These programs require manufacturers to demonstrate compliance with their standards through testing in independent laboratories. A fourth program, the Electronic Environment Product Assessment Tool (EPEAT), from the USEPA in partnership with the Green Electronics Council, specifically targets electronic office equipment. This program focuses primarily on energy efficiency and environmental impacts associated with the manufacture, use and disposal of electronic office equipment. It also requires manufacturers to reduce or eliminate environmentally sensitive materials. In addition, EPEAT does not yet accept product emissions. See *Standards and Guidelines* below for more information.

Differentiation. As noted, manufacturers are creating environmentally friendly products and participating in voluntary certification programs as a way to differentiate their products in the marketplace. Environmentally friendly products generate trust and good will among consumers. 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 Equipment Output Includes Indoor Air Pollutants

As with many other types of manufactured products, the components and materials required for constructing and operating electronic office equipment can emit VOCs. The USEPA has reported that ozone and respirable particles may be emitted continuously or episodically during operation and during component failures or poor operation (USEPA 1995). Volatile organic compounds, SVOCs and particulates also can be emitted by paper processing during printing and copying (Wolkoff et al 1993).

Researchers from the Lawrence Berkeley National Laboratory, the University of California at Berkeley and Arizona State University, Tempe conducted a comprehensive review of the studies from the past 10 years as well as conducted their own study of emissions from computers and printers (Destaillats et al 2007). The following offers some highlights of the results of their review. Readers interested in more details about the studies cited below are encouraged to read the review in its entirety.

Desktop and notebook computers. The scientific literature shows that computers emit a range of VOCs, although in most cases the emission rates are relatively low, suggesting that computers are not as a big contributor as other sources. Computers also do not seem to be a source for ozone. Typically TVOC emissions were higher for computer with cathode-ray tube (CRT) than with thin-film transistor (TFT) monitors. Reported VOCs for desktop computers include aromatic hydrocarbons, alkanes, alcohols, ketones and formaldehyde. Emission rates are lower for notebook computers, both when they are in idle or operating conditions. For notebooks, VOCs emitted include alcohols, carboxylates and ketones (Hoshino et al 2003). Plastic covers of video-display units emitted triphenylphosphate flame retardants (Carlsson et al 2000).

Printed circuit boards held at an elevated temperature of 60 degrees C emitted several polybrominated diphenyl ether flame (PBDE) retardants (Kemmelein et al 2003a). Production and use of PBDEs have been phased out in Europe, voluntarily restricted in Japan (Kemmelein et al 2003b) and the California legislature has banned two PBDE products from use in that state. There is concern, however, that new units made with recycled plastics containing high residual PBDE levels could still emit PBDEs (Morf et al 2005).

One interesting finding is there no clear and consistent evidence of a significant relationship between levels of bromated flame retardants (BFRs) and electronic equipment and polyurethane foam-containing furniture. Yet, the results of this same study demonstrated that when an old computer was replaced with a new model in one of the room, there was an appreciable decrease in BFR levels (Hazrati and Harrad 2006).

Results of another recent study showed that between 4.0 mg and 6.3 mg of dust per day can be released during computer operation, which suggests that people working near this equipment could possibly be exposed to chemicals that are found in the dust, such as PAHs. This study also found that the amount of PAHs in dust samples collected from the inside of computers was three times higher than what was measured in outdoor air samples (Ren et al 2006). Of note, no study as yet has quantified the exact contribution of office equipment emissions to indoor levels of PAHs. Also of note is computers do not generate particulates, but will release fine particles of dust that have collected in their interiors.

Printers and photocopiers. In general, VOC emission rates from photocopiers are much higher than for printers and multifunctional devices, such as those that include a fax machine, printer and copier all in one. Printers and copiers also have higher emission rates than computers, particularly for styrene, toluene, xylene and other alkylbenzenes (Destaillats et al 2007). The heating of toner during printing is among the sources of VOC emissions. Results from a number of studies have shown that laser printers and photocopiers generate ozone in varying amounts (Smola et al 2002, Lee et al 2001, Leovic et al 1996, Leovic et al 1998, Kagi et al 2007, Lee and Hsu 2007).

Researchers also have investigated emissions of ultrafine particles from toner and paper dust formed during the laser printer and copier operation (Wensing et al 2006, Lee et al 2001, Kagi et al 2007, He et al 2007, Lee and Hsu 2007). Recent studies, conducted by researchers from Queensland University of Technology in Australia, characterized particle emissions ($PM_{2.5}$) of 62 office printers. These studies included three steps: 1) monitoring indoor (office building) and outdoor ultrafine particle concentrations for more than 48 hours; 2) measuring particle concentration levels in the vicinity of all of the printers in an office building; and 3) measuring particle concentrations and emission rates from three different printers in an environmental chamber (for more information about how this technology is used to evaluate VOC and particle emissions, see *Measuring Emissions Using Environmental Chamber Technology* below). Based on the results, the researchers divided the printers into four categories: non-emitters, and low, medium and high emitters. Approximately 60 percent of the printers did not emit submicrometer particles, and of the 40 percent that did, 27 percent were high particle emitters. Particle emission characteristics from the three laser printers studied in the environmental chamber showed that particle emission rates are printer-type specific and are affected by toner coverage and cartridge age (Congrong et al 2007).

Results of earlier studies echo the findings of the studies cited above, including the following:

- Aromatics and siloxanes are emitted by computer circuit boards, monitors and printer toner (Brooks and Davis 1992).

- Esters and acrylates may be used as coalescing agents or as monomers in polymer-based products (Wolkoff et al 1993)

- Particles may become airborne as copiers and printers transfer toner to the printed page.

- Ozone may be generated from office machines through the use of electric charging devices during the copying and printing processes.

- Phthalates may be released from resins in circuit board and component materials. Carbon black also can be released from toners, which are generally a mixture of plastic resin, carbon black and other additives (London Hazard Centre 2002). Carbon black consists of particles and impurities that can be inhaled.

The International Centre for Indoor Environment and Energy conducted a study on electronic equipment, including computer monitors. The study consisted of sensory evaluations people working in offices with computers. The results showed that the air quality was significantly poorer in the offices with computers and monitors compared with empty offices. 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 (Wargocki 2001).

ECT Meets the Challenge of Measuring VOC and Particle Emissions

Measuring emissions of potential indoor air pollutants from electronic office equipment offers some unique challenges. Links to some pollutants, such as organophosphate flame retardants are fairly well established, but other indoor air contaminants, such as VOCs, ozone, polycyclic aromatic hydrocarbons (PAHs) and phthalates esters (a type of SVOC) can come from a variety of sources. Adding to the challenge is the diversity of the available equipment, the rapid evolution and turn over of product lines, and the various environments and operating conditions in which the equipment is used (Destaillats et al 2007).

To overcome these challenges, researchers are using dynamic environmental chamber technology (ECT) to mimic real world conditions while controlling indoor air variables, such as temperature, humidity and airflow. 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. The results of these tests demonstrate what and how much these products emit, which may not be otherwise possible, given the uncontrollable variables in buildings and other potential sources for these indoor contaminants. This method also allows a product to produce emissions similar to the way the product would emit in a home, office or school. The collected data is then mathematically modeled to determine exposure concentrations produced by product application in many different indoor environments. See *Technology Leadership Starts With Product Testing* below for more information on how Air Quality Sciences pioneered this technology and how the company uses ECT today to assist manufacturers create safer products.

Air Quality Sciences has studied the emissions from process photocopies, laser printers and computers since 1994, and has participated in the development and validation of test protocols. A review of the data was recently published. The results showed a wide range of total VOC (TVOC), ozone and particle emissions from the equipment, with dry process photocopiers having the highest average TVOC and ozone emission rates and laser printers having lower average TVOC and ozone rates. Personal computers were not a source of ozone, but they did emit TVOC and particles. Particle emissions from the laser printers and photocopiers were similar, with personal computers emitting lower levels of particles. Table 1 provides a summary of the emission rate data for office equipment (Black 2006).

Table 1. Summary of Emission Rate Data for Office Equipment (Black 2006)

Equipment / Processes	**Average Contaminant Emission Rate mg / h (Range of Values)**		
	TVOC	**Total Particles**	**Ozone**
Laser Printers	26.4 (1.2 – 130)	0.9 (<0.02 – 5.5)	0.8 (<0.02 – 6.5)
Dry Process Copiers	36.4 (4.6 – 108)	2.5 (<0.7 – 6.2)	4.2 (1.2 – 6.3)
Personal Computers	12.2 (0.05 – 24.2)	0.05 (<0.027 – 0.12)	<0.02

Emission rates are expressed as milligram of contaminant emitted per hour (mg/h) of equipment operation. Background emissions were measured from printers and photocopiers, which were energized, but not actively printing. Total VOC 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 (Worthan and Black 2007).

Table 2 lists individual VOCs commonly emitted from these products. Common sources include electronic components and adhesives, electronic and heating processes, inks and toners, papers and transparencies, plastics, flame retardants, and cleaning solvents.

Table 2. Primary (Individual) VOC Emissions from Office Equipment (Black 2006)

Laser Printers	Photocopiers	Computers
1-Butanol	Acetaldehyde	1-Phenylethanone
Acetophenone	Toluene	2-Ethyl-1-hexanol
Ethylbenzene	Benzaldehyde	Ethylbenzene
Formaldehyde	Ethylbenzene	Ethylhexylpropenoic ester
Acetaldehyde	Formaldehyde	Phenol
Toluene	Hexane	Methylacrylate
Octamethyl-Cyclotetrasiloxane	Nonanal	Formaldehyde
Pentamethylheptane	Octanal	Toluene
Styrene	Styrene	Xylenes
Xylenes	Xylenes	Butylacetate

Another example of how ECT can be used to measure VOC emissions from office equipment is illustrated in a Syracuse University study. The investigators measured emissions from potential sources found in a typical office cubicle, including personal computers, printers, copiers, carpets and an office workstation, which consisted of desk, chair, cabinet, and partitions. Depending on the size and type of the sources, mid-scale (5 m^3) and full-scale (22.1 m^3 and 54.37 m^3) stainless steed chambers were used to measure and identify the emissions from individual sources. The sources were divided in active and passive categories. Active sources (personal computers, printers and copiers) emitted heat and indoor air pollutants and also were dependent on operational modes. Passive sources included the partitions and furniture (Berrios et al 2005).

Three different desktop computers were tested: one with a TFT monitor and two with CRT monitors. The results showed that the VOC emission rates for the computers were about 10 to 120 times higher when the computers were turned “on” than when there were turned “off.” All three computers emitted m-xylene, p-xylene, pentadecane, phenol and toluene. In addition, the computers with the CRT monitors had slightly higher VOC emissions than the computer with the TFT monitor (Berrios et al 2005).

Three printers (two laser jets and one ink jet) and a copier also were evaluated. The results from these tests indicated that the emissions rates from printers and copiers during the “off” and “idle” periods were negligible compared with high emissions during the operating and post-operating period. Toluene was the only common VOC found in the emissions of all three printers. One printer emitted very high levels of d-limonene (50% of all its emissions) (Berrios et al 2005). This is noteworthy because d-limonene was also the most common VOC found emitting from the passive sources.

For the passive sources, each component of a workstation system was tested individually. The tested components were: chairs, carpet, drawer, table surface and partitions (panels). From these tests, the results showed that VOC emissions from the furniture decayed very slowly after the first few days. In addition, passive sources generally had lower emission factors with chairs being the lowest. With respect to potential building occupant exposures, the investigators concluded that based on the results of this study, printer, copier and computer operations had significant impact on the overall VOC concentrations in a typical office environment (Berrios et al 2005).

Health Impacts From Inhaling Chemical and Particulate Emissions

Airborne chemical and particulate contaminants, including potential carcinogens, reproductive toxins, and irritants, are 2 to 10 times higher indoors when compared with outdoor levels. While scientists and medical professionals have not yet determined the full extent of negative health effects caused by these contaminants, researchers have demonstrated that a number of symptoms and respiratory problems have been associated with exposure to chemical and particulate emissions in indoor air. In an USEPA study, for example, 30 people had a significantly increased perception of headache, mucous membrane irritation, and dryness in the eyes, nose and throat as well dry and tight facial skin when exposed to the operating electronic equipment in the environmental chamber (Wargoki 2001)

Volatile organic compounds are known to cause eye, nose and throat irritation; cough; headache; general flu-like illnesses; skin irritation; and some can cause cancer. Others produce odors that may be objectionable and may lead to headache, upper respiratory irritation and nausea. Odors also provide a “fear of the unknown” among occupants, which may lead to anxiety. Complicating matters is the potential for interactions of VOCs with other chemical compounds to form a third compound that also may be a threat to health and comfort. As a result, even though the concentrations of individual VOCs may be well below odor thresholds or known toxic levels, their occurrence by themselves or in complex mixtures may lead to perceived poor indoor air quality or irritation among those exposed

Inhaling particulates can cause eye, nose and throat irritation and increase the risk for respiratory infections. Health care professionals are especially concerned about the long-term effects of inhaling fine particles (less than 2.5 µm – also referred to as $PM_{2.5}$ or fine PM), because they can travel deep into the lungs where they can remain embedded for years or be absorbed into the bloodstream. Inhalation of fine PM has been linked to increases in respiratory health problems such as asthma, bronchitis, pneumonia and emphysema; hospitalization for heart or lung disease; and even premature death.

Carbon black, a key component of photocopier toner, may contribute to particle emissions. It is a black, odorless powder, pellets or paste. The London Hazards Centre’s fact sheet on photocopier and laser printer hazards outlines the health impacts of many of the different compounds and pollutants that can be emitted from these types of office equipment. Table 3 summarizes the health consequences according to that document (London Hazards Centre 2002).

Table 3. Health Effects Associated With Emissions From Photocopiers and Laser Printers

Chemical Emitted	Health Effect
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
Carbon black	Irritated eyes, headache, itching skin

Exposure to Indoor Air Pollutants Places Children At Risk

Children are more vulnerable to exposure and face greater environmental health risks to indoor pollutants than adults. Their organs and immune and neurological systems are still developing, and because of their lower body weight, they breathe in a relatively greater volume of air than adults. This results in a higher body burden of air pollutants for the same amount of exposure. A recent study, for example, found that children exposed to high levels of VOCs were four times more likely to develop asthma than adults (Rumchev et al 2004). With the increased use of office equipment in schools, exposure of children is cause for concern.

A growing number of scientists also are concerned that exposure to very small traces of VOCs and some industrial chemicals in homes and schools may have profound impacts on fetuses, newborns and children, including disruptions to the endocrine system (hormones), gene activation and brain development. An especially striking finding is some chemicals may have health impacts at extremely low levels, which are not seen at higher levels. Minute levels of phthalates, for example, which are used to make toys, building materials, drug capsules, cosmetics and perfumes, have been linked to sperm damage in men and genital changes, asthma and allergies in children (Waldman 2005).

Researchers at the University of London suspected that small amounts of some environmental chemicals might have a dramatic effect on hormone levels. They tested the hormonal strength of 11 common chemicals, known to mimic estrogen. Alone, each chemical was very weak, but when low doses were mixed with natural estrogen, the strength of estrogen doubled (Waldman 2005, Rajapakse et al 2002). High levels of estrogen are associated with some forms of cancer and developmental problems during puberty.

Standards and Guidelines

Presently, there is no federal law or regulation obligating manufacturers to monitor product emissions. However, some states and organizations have implemented emissions standards, at least where state-funded projects are concerned. In addition, international groups, particularly in Europe and Canada, are taking active steps to encourage manufacturers to manage their product emissions. The following briefly describes some prominent examples of both voluntary and regulatory programs.

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. For more information, visit the California Proposition 65 website at www.oehha.ca.gov/prop65.html.

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. For more information visit the State of Washington's Indoor Air Quality website at www.dog.wa.gov/ehp/ts/IAQ/defaut.HTM.

California Air Cleaner Regulation

California Assembly Bill 2276, signed by Governor Arnold Schwarzenegger in September 2006, directs the Air Resource Board (ARB) to develop and adopt a regulation to limit the ozone emitted from indoor air cleaning devices in order to protect public health. The bill requires the ARB to adopt the regulation by December 31, 2008. Among the provisions are to create an ozone emission concentration standard that is equivalent to US Federal Drug Administration (FDA) limit of 0.05 ppm. Devices must be tested using ANSI / UL Standard 867, 2007 Section 37 revision, which is the standard presently used by industry and includes 24-hour chamber test to determine emissions. Manufacturers also must submit applications and test data for ARB certification, and have to meet specific labeling, packaging and sales materials requirements (California ARB 2007). While this regulation applies to air cleaning devices sold in California, it provides excellent guidance on emission levels that can be applied to all electronic devices that produce ozone. For more information about this regulation, visit the ARB website at http://www.arb.ca.gov/research/indoor/aircleaners/aircleaners.htm.

Federal Agencies

Although there are no federally mandated indoor air quality standards, the USEPA has encouraged the development and control of emissions of office equipment, as well as other indoor products, including publishing 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. The USEPA does have mandatory requirements for outdoor air. The National Ambient Air Quality Standards (NAAQS), which control the amount of numerous pollutants, including ozone and respirable particles, are used as default standards for indoor air.

Electronic Environment Product Assessment Tool

Electronic Environment Product Assessment Tool (EPEAT), from the USEPA in partnership with the Green Electronics Council, specifically targets electronic office equipment. This program focuses primarily on energy efficiency and environmental impacts associated with the manufacture, use and disposal of electronic office equipment. It also requires manufacturers to reduce or eliminate environmentally sensitive materials, such as cadmium, mercury, lead, hexavalent chromium, flame retardants, plasticizers, and polyvinyl chloride and chlorinated plastics. There are discussions to add reduction and elimination of VOCs to EPEAT's requirements. Presently, manufacturers are not required to independently verify compliance at the time the product is registered, although EPEAT periodically selects products from its registry and verifies that the product actually meets the criteria as declared (EPEAT 2007). For more information about EPEAT, visit the program's website at www.epeat.net.

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. GREENGUARD has standards for both active electronic equipment, such as printers and photocopiers, and stationary equipment, such as computers and monitors. Standards are based on globally recommended limits for product emissions, and the printer standard has been harmonized with Blue Angel's standard. GREENGUARD has additional requirements for formaldehyde, respirable particles and phthalates. GREENGUARD Certified products are recognized as a part of the United States Green Building Council's LEED Programs and California's CHPS School Program. Emission requirements cover general VOCs, styrene, particles, formaldehyde and ozone. For more information about GREENGUARD, visit the program's website at www.greenguard.org.

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 TVOC, benzene, styrene, particles and ozone. For more information about Blue Angel, visit the program's website at www.blauer-engel.de.

EcoLabel Program (Canada)

Launched by the Canadian federal government in 1988, the EcoLogo Program serves buyers and sellers of green products throughout the United States and Canada, and around the world. The

EcoLogo criteria development process follows the principles and practices identified in the ISO 14024 standard for Environmental Labeling. EcoLabel's office equipment criteria cover multifunction devices, printers, copiers, fax machines and mailing machines. These criteria establish requirements for ozone, dust emissions, chlorofluorocarbons (CFCs), energy use and compatibility with recycled paper. At this time, EcoLogo does not have any criteria that address VOC or particle emissions from computers and monitors. For more information about EcoLabel, visit the program's website at www.ecolabel.org.

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, visit the WHO website at www.who.int/en/.

Technology Leadership Starts With Product Testing

To meet market demand and reduce product liability risks, product manufacturers will increasingly need to demonstrate their technology leadership by testing and monitoring product emissions to ensure their products emit low levels of VOC, SVOCs and particles, and potentially reformulate or re-engineer those products that do not comply with testing limits. As noted above, environmental chamber technology is the most reliable and scientifically proven way to measure VOC emissions and to understand process parameters.

Air Quality Sciences pioneered environmental chamber testing technology more than 18 years ago and actively participated in establishing the methodology used to test products. This testing methodology was further developed by consensus during an official dialogue among various stakeholders and the US Environmental Protection Agency and has been adopted by ASTM International as D 5116-97, Standard *Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products*, and D 6670-01, *Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products*. AQS has specific test protocols that have been developed for office equipment certification.

Air Quality Sciences recently became the first company worldwide to receive International Standards Organization (ISO) / International Electrotechnical Commission (IEC) 17025 accreditation for testing protocols for indoor environments and products. ISO/IEC 17025 is an internationally recognized and rigorous measurement standard that allows an organization to prove its competence. This accreditation complements AQS' achievement of ISO 9001 registration along with accreditation by Germany's Blue Angel environmental program, American Industrial Hygiene Association's (AIHA) EMLAP accreditation, and verification by the State of California for performing Green Label Plus testing

AQS Test Results. Office equipment 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, AQS consultants can assist manufacturers analyze results and propose potential solutions.

AQS Testing Options. AQS offers a suite of testing options to manufacturers, including a Basic Test Protocol, Component Protocol, Odor Protocol, Risk Assessment, GREENGUARD Certification Protocol, and Blue Angel Protocol. The following is a brief description of each.

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 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 noncancer 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 USEPA and other available 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 establish acceptability of their product to meet regulatory requirements and to minimize risks.

Certification Protocols

Manufacturers can apply to voluntary certification programs like the GREENGUARD Certification Program for low emitting electronic equipment. 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 pre-qualify products for the program, or official program testing can be completed for application submittals. Testing protocols are also available for qualification for additional programs such as Germany's Blue Angel Emission requirements.

Product Emissions Testing Offers Major Benefits

Those who embrace a strategy of product emissions testing and monitoring and/or responsibly using products that are certified as low emitting will realize major benefits, including:

- Open opportunities into green markets
- Increased goodwill and positive PR associated with industry leadership in addressing public health issues and providing green products for consumers and users
- Reduced risk of product liability lawsuits
- Fewer product-related odor and irritation complaints from building occupants

AQS is well positioned to assist manufacturers of electronic office equipment create and maintain healthy indoor environments by offering the most complete and sensitive testing. AQS also employs experts who can help manufacturers modify their product to be the best performers and the best at protecting the indoor environment and building occupants.

Visit us at www.aqs.com to learn more about how environmental chamber testing can help you, or call us at (770) 933-0638 and ask for Product Evaluations to order the analysis. Also visit the AQS Aerias IAQ Resource Center to learn more about VOCs and other indoor pollutants. Aerias may be accessed from the AQS website or at www.aerias.org. For a listing of products that are certified to emit low levels of VOCs, visit the GREENGUARD Environmental Institute site at www.greenguard.org.

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