# Protecting Children's Health

In 1981 the Select Panel for the Promotion of Child Health – a US government group of leading health care professionals – noted: "Children are one-third of our population and all of our future." Even though more than 25 years later, children now comprise about one-fourth of the US population, the sentiment remains the same and underscores the importance of ensuring children are given every chance to grow, develop and thrive in healthy indoor environments where they spend most of their time. This research report seeks to raise awareness about how poor indoor air quality (IAQ) can affect children's health by answering the following questions:

Why are children at more risk than adults?

How many children are at risk?

Which indoor air pollutants are of most concern?

What are the possible connections between the alarming increase in childhood asthma and autism and indoor air pollution?

What can be done to protect children's health against indoor air contaminants, particularly in schools?

## Why Are Children At More Risk Than Adults?

Physical differences and socioeconomic status are among the key reasons why children are more vulnerable to exposure and face greater environmental health risks to indoor pollutants than adults. Their organs and respiratory, 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. In addition, newborns breathe through their mouths, as do many older infants and children – more so than do adults. This difference in breathing may increase children's risk of pulmonary exposure to particulates and fibers, which might otherwise be filtered out in the nose. Also, children's breathing zones are much closer to the ground than adults, and as a result, heavier airborne chemicals pose more of risk to children than to adults. In addition, children have a higher heart rate than adults, which allows substances that are absorbed into the blood to permeate tissues faster (Flynn et al 2000). These factors combine to create a higher body burden of air pollutants for the same amount of exposure.

Further, more children in the US live in poverty than any other age group. As a result, these children are more likely to live in public housing or blue-collar neighborhoods in close proximity to industry – a primary source of outdoor air pollution which can be brought indoors via heating, ventilating and air-conditioning (HVAC) systems. In addition, public housing, especially apartment homes in urban settings, is more likely to have cockroach, rodent and mold infestations. Allergens from cockroaches, rodents and mold are known allergy and asthma triggers. Analysis of data from a national sample of 17,110 children ages zero to 17 years indicate that all children living in urban settings are at increased risk for asthma (Aligne et al 2000). In addition, the public health departments of Seattle and Kings County, Washington analyzed trends in local hospitalizations for children with asthma from 1987 to 1998. The results showed that the youngest children in the poorest urban communities have the highest rates on asthma hospitalizations (Solet et al 2000). Children living in poverty also may not take advantage of health care services as often as other socioeconomic groups, so underlying chronic illnesses, such as asthma, may not be diagnosed (Flynn et al 2000). For example, a study of Detroit, Michigan school children in the third to fifth grades found that 14.3 percent might be under diagnosed for asthma (Joseph 1996).

## How Many Children Are At Risk?

The level of risk for each child is difficult to determine. How a child may react to indoor air pollution varies a great deal depending on the child's overall health and whether the child is more or less sensitive to a particular indoor air contaminant. The conditions in which children live and the amount of time spent indoors are also factors. For more about health effects associated with indoor air contaminants see the discussion below on *Which Indoor Air Contaminants Are of Most Concern?*

### Age, Health, Living Conditions

Age alone is a risk factor as noted above. Also, as noted above, children living in urban areas and from low-income families have an increased risk from indoor air pollution, especially for developing allergies and asthma. Another mitigating factor is overall health. Children with chronic and/or high-risk illnesses may be at more risk as their respiratory and immune systems are weaker and as a result they may be more sensitive to indoor air contaminants than healthy children. For people confined indoors due to illness, the consequences can be more severe than for the general population (Cohen 2006). The Centers for Disease Control and Prevention's (CDC) National Health Interview Survey 2002 and 2003 lists the following as high-risk medical conditions in children: Cystic fibrosis, sickle cell anemia, diabetes, congenital heart disease, other heat disease and conditions, asthma, cerebral palsy, muscular dystrophy, down syndrome, birth defects, other developmental disorders, mental retardation, transplants, cancer, HIV/AIDS, end stage renal disease (ESRD) and seizures (Lu et al).

Table 1 provides some useful statistics that quantify how many children may be at risk from indoor air pollution. For more information, see the AQS research report *Asthma and Damp Buildings: Making the Connection*, which are available free from the Aerias AQS IAQ Resource Center (**www.aerias.org**).

**Table 1.** Children At Risk From Indoor Air Pollution

| Children in the US | Estimate |
|---|---|
| Under the age of 18 | 73 million* |
| Living under the poverty level | 12.5 million* |
| Living in high poverty areas | 14.7 million+ |
| With chronic and/or high risk medical conditions | 2.5 million** |
| With asthma | 6.2 million* |

* America's Children in Brief: Key National Indicators of Well-Being, 2006

** Lu et al

+ Kids Count Data Series, 2000

### Time Spent Indoors

Time of exposure to indoor air pollutants is another risk factor for adverse health impacts. Because children comprise California's largest sensitive population group with respect to toxic effects of air pollution, the California Air Resources Board (CARB) authorized a study of children's activity patterns in that state. Previous studies of children's activities did not obtain specific location information or include large enough sample for reliable estimates, according to CARB. In this study, 1,200 English speaking children 11 years of age or younger were interviewed from spring 1989 to winter 1990. The participants were asked if they used or were near sources of pollution, such as environmental tobacco smoke (ETS), solvents, pesticides, paint and gas appliances. The results showed that overall children spent on average 85 percent of their time indoors; 70 percent of that time at home. These results agree with estimates from other studies in the US and other industrialized nations (Wiley et al 1994). For more information about this study, see the AQS research report *Indoor Air Quality & Sensitive Populations Groups*, which may be accessed free of charge from the AQS Aerias IAQ Resource Center, under the Premium Content tab, at **www.aerias.org**.

## Which Indoor Air Contaminants Are of Most Concern?

To answer this question requires understanding that indoor air is an intriguing, complex environment that contains a myriad of visible and invisible contaminants. Airborne pollutants, including potential carcinogens, reproductive toxins, and human irritants, are 2 to 10 times higher indoors when compared with outdoor levels and can be as much as 1,000 times higher in newly constructed and renovated indoor spaces. These visible and invisible contaminants generally fall in one of two categories: (1) particulates or (2) gases, vapors and odors. The following provides a brief description of each category and the health problems associated with them. For more detailed information about these indoor air contaminants, see the AQS research report, *Clearing the Air on Indoor Air Cleaners / Purifiers*, which is available at no cost under the White Paper tab of the premium content section in the AQS Aerias IAQ Resource Center website (**www.aerias.org**).

**Particulates: Size is Everything**

Particulates are particles that are small enough to suspend in the air. Suspended inorganic particles, such as metals (lead, mercury); dust; pollen; asbestos and other fibers; car, bus and truck exhaust; or ETS and other types of smoke, are often referred to as *aerosols*. Suspended organic compounds and small living organisms, such as bacteria and viruses; mold spores and pieces of mold colonies; dust mite feces and body fragments; cockroach body parts; and dander from cats, dogs and other mammals, are called *bioaerosols* (McDonald and Ouyang 2000). Allergens, associated with grasses, pollen, dogs, cats, dust mites, cockroaches and mice to name a few common examples, also fall into this category. Particles can range in size from very small (0.001 µm to 10 µm), which can remain in the air for a long time, up to relatively large (100 µm), which quickly settle out of calm air (ALA Special Report on Air Cleaners).

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 have 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. The results of numerous studies have demonstrated a correlation between adverse health effects and the level of fine PM. In response, the US EPA has established an aggressive program and standards to reduce fine PM levels in outdoor air. These same concerns also apply to indoor air in schools and other environments where children spend their time. For more information and a comprehensive review of these studies, see Dockery et al 1993; Moolgavkar, Dockery and Pope 1994; Godleski et al 2000; US EPA Provisional Assessment of Recent Studies on Health Effects of Particulate Matter 2006; and the US EPA website on particulate matter, **www.epa.gov/oar/particlepollution**.

Larger particles (greater than 10 µm) do not cause as much concern, because they get caught in the nose and throat and are cleared from the respiratory tract by coughing or swallowing (ALA Special Report on Air Cleaners).

**Gases, Vapors and Odors: What You Can't See Can Hurt You**

The types of gases or vapors most often found in indoor environments include combustion byproducts, such as carbon monoxide, nitrogen oxides, sulfur dioxide, soot particles and polycyclic aromatic hydrocarbons (PAHs); phthalates; pet, human and cooking odors; ETS; volatile organic compounds (VOCs); and microbial VOCs and mycotoxins. Many of these substances also produce odors, some of which are pleasant while others can be distracting and irritating.

**Volatile Organic Compounds.** Among the most prevalent of all indoor air constituents are volatile organic compounds (VOCs), with as many as 100 to 1,000 different VOCs in the air where children can easily inhale them. Some VOCs can 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. Complicating matters is the potential for interactions of VOCs with other chemical compounds to form a third compound that also may be a threat. As a result, even though the concentrations of individual VOCs may be well below odor thresholds or known toxic levels, their occurrence in complex mixtures may lead to perceived poor IAQ or irritation among those exposed.

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, Bornehag et al 2004).

In a 2006 review study, researchers from the Harvard School of Public Health and the Mount Sinai School of Medicine systematically examined publicly available data on chemical with the goal of identifying the industrial chemicals that are the most likely to damage developing brains. The researchers found that 202 commonly used industrial chemicals have the capacity to damage the human brain, and they concluded that chemical pollution may have harmed the brains of millions of children worldwide. About one-half of them are considered high-volume production chemicals. The authors also concluded that the toxic effects of industrial chemicals on children have generally been overlooked (Grandjean and Landrigan 2006, Grandjean and Perez).

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. For more information about results of studies linking environmental contaminants to illnesses, see Cohen 2006.

At this time, research in this area is still new, and as yet results do not present a clear picture. One study of particular note, the National Children's Study, sponsored by the US EPA and the Centers for Disease Control and Prevention (CDC), is in progress with results expected in 2010. By the time the study is completed, about 100,000 children at various ages from birth to puberty will have participated. Among the primary goals is to investigate the associations between exposures to environmental pollutants, such as VOCs among others, and health problems, especially asthma, autism, attention deficit disorder and alterations at puberty caused by hormonal disruptions and other neurobehavioral and neurocognitive disorders (Özkaynak et al 2005).

**Microbial VOCs and Mycotoxins.** Moisture also is a vapor that must be monitored as too much moisture can support indoor mold growth. Some types of mold also emit VOCs, known as microbial VOCs or MVOCs, which are responsible for the characteristic musty, earthy odors associated with mold. Children who are sensitive to MVOCs may experience eye, nose and throat irritation. A wide variety of molds also can produce mycotoxins at various times during their lifecycles. Children can experience potentially serious health problems if they are exposed to high levels of these compounds, but this is rare in most indoor environments.

**Environmental Tobacco Smoke.** Although becoming a lesser issue in public buildings, ETS is still found in many homes, which can be particularly dangerous for children. Exposure to passive smoke or ETS is well documented as a major risk factor for respiratory problems and cancer, and the US Surgeon General has determined that there is no risk-free level of exposure to ETS (CDC 2006). Environmental tobacco smoke alone contains more than 4,700 airborne substances, including gases and particles from incompletely burned tobacco, of which 243 are known carcinogens. Children, who are exposed to ETS, are more likely to develop lower respiratory tract infections, bronchitis, pneumonia, middle ear disease, sudden infant death syndrome (SIDS) and respiratory symptoms (CDC 2006). Secondhand smoke (ETS) can also play a role in the development and exacerbation of asthma.

According to the CDC, nearly 60 percent (22 million) of children ages 3 to11 years are exposed to secondhand smoke and about 25 percent of those children live with at least one smoker, as compared with 7 percent of nonsmoking adults (CDC 2006). Younger boys (ages 0 to 2 years) spend more time around ETS than older boys, and more girls spend more time around ETS than boys, all which are indicative of children's typical activity patterns. Girls and younger children spend more time indoors than boys and older children (Wiley et al 1994).

**Poor IAQ in Schools.** Because children spend a great deal of time at school, maintaining good indoor air quality in these environments is critical for minimizing their exposure to potentially dangerous indoor air pollutants. Air Quality Sciences, Inc. (AQS) has measured VOC levels in more than 200 US schools and found 345 different VOCs in the indoor air. Table 2 lists the 15 most common VOCs found in these schools. Other frequently found VOCs of concern in schools include perchloroethylene and methylene chloride, potential carcinogens related to spot cleaners, degreasers, and art supplies.

**Table 2. Common VOCs found in schools**

| VOC | Source(s) | VOC | Source(s) |
|---|---|---|---|
| Toluene | Cleaners, construction materials | Hexanal | Cleaners, adhesives, deodorizers |
| Xylenes | Cleaners, construction materials | 2-Butoxyethanol | Wood cabinetry, cleaners, paints |
| Siloxanes | Waxes, polishes, deodorants | TXIB | Cleaners, paints |
| Formaldehyde | Furniture, ceiling tile, wood shelving, cabinetry | Ethanol | Disinfectants |
| Hexane | Markers, cleaners | Acetaldehyde | Plastics, paints |
| Acetone | Markers, art supplies | Longifolene | Cleaners, wood products, flooring |
| 1,4 Dichlorobenzene | Cleaners, deodorizers | Naphthalene | Adhesives, art supplies |

The AQS test results also showed that the average total VOC (TVOC) level was 276 $\mu g/m^3$, with a minimum of 1.7 $\mu g/m^3$ and a maximum of 4600 $\mu g/m^3$. Most standards and guidelines consider 200 $\mu g/m^3$ to 500 $\mu g/m^3$ TVOC as acceptable. Levels higher than this may result in irritation to some occupants. While TVOC is a good indicator of elevated VOCs and complicated VOC mixtures may lead to irritation, minimizing the presence of specific chemicals with known health hazards is required.

**Formaldehyde in Schools.** Formaldehyde exposure is a major concern in schools, particularly in those that use portable classrooms. Formaldehyde is used widely by industry to manufacture building materials and numerous household products, and also is a by-product of combustion and certain other natural processes. Primary sources include pressed wood products such as particleboard, plywood, and medium density fiberboard (MDF); finished furniture, shelving, and cabinetry made with composite boards and certain coatings; decorative fabrics and textiles; and paper products. It also may be used as a biocide in certain paints and coatings, adhesives and personal care items.

Based on more than 300 measurements collected in residences, office buildings and schools, AQS studies have found typical concentrations range from 0.01 ppm to 0.03 ppm in office buildings and 0.05 ppm to 0.08 ppm in homes. An average level of 0.04 ppm has been found in schools, with new or recently renovated or refurbished school environments reaching 0.14 ppm. The levels found in schools are higher than the 0.027 ppm (27 ppb) limit recommended by the state of California's Evironmental Protection Agency for an eight hour exposure period.

Available clinical and epidemiological data indicate that individual responses to formaldehyde may vary substantially. Irritation may occur at levels of 0.08 ppm or less, and odor detection has been measured as low as 0.03 ppm. When formaldehyde is present in the air at levels exceeding 0.1 ppm, some people may experience watery eyes; burning sensations of the eyes, nose, and throat; coughing; wheezing; nausea; and skin irritation. Some people are very sensitive to formaldehyde, while others have no reaction to the same level of exposure. Other health effects include coughing, fatigue and severe allergic reactions. High concentrations also may trigger asthma attacks.

**Associating Poor IAQ With Health, Learning and Productivity.** According to the US Department of Education nearly 73 million people in the US, including 68.5 million children (6 million of which have asthma), spend a significant amount of time each day in more than 120,000 public and private schools (Common Core Data 2002). Many of the school buildings are in poor condition, which accounts for the US EPA's estimate that 50 percent of US schools have IAQ problems.

As a part of its review and assessment of the health and productivity benefits of green schools, the National Research Council found "a robust body of evidence indicating that the health of children and adults can be affected by air quality in a school," and "a growing body of evidence [suggesting] that teacher productivity and student learning, as measured by absenteeism, may be affected by indoor air quality as well" (National Research Council 2006). The California ARB reached a similar conclusion in its report to the California Legislature on the quality of indoor air in that state (CARB 2005).

The National Research Council of the National Academies' interim report, *Review and Assessment of the Health and Productivity Benefits of Green Schools* (2006) also noted that the body of available research suggests an association between the condition of a school building and student achievement. All of the studies analyzed by the committee found that student test scores improved as the physical condition of school buildings improved. The degree of improvement of students' test scores varied across the studies, but in all cases students in buildings in better condition scored higher than students in buildings in poor condition" (National Research Council 2006).

One study offers an illustrative example. This study examined the ventilation rates in 55 fifth grade elementary school classrooms and student performance based on standardized math and reading tests. The results showed that increased ventilation rates had a significant impact on math and reading test scores. With a ventilation rate of less than 5 cfm the mean math scores were 56.32 and the mean reading scores were 47.73. When ventilation rates were over 10 cfm mean math scores were 64.46 and reading scores were 54.27. This represented a 14.7 percent increase in math scores and a 13.7 percent increase in reading scores with improved ventilation (Shaughnessy et al 2006).

For more information see the US EPA's pamphlet Indoor Air Quality & Student Performance, which is available online at **www.epa.gov/iaq/schools**. Also, a searchable bibliography of studies dealing with indoor health and productivity (including abstracts of many of the references cited below) is available through the Indoor Health and Productivity (IHP) project, which may accessed at **http://www.IHPcentral.org**.

## What are the Possible Connections Between the Alarming Increase in Childhood Asthma and Autism and Indoor Air Pollution?

In recent years, educators, parents, physicians and pubic health officials have been very concerned about the dramatic increase in the number of children who have developed asthma and possible connections to indoor air pollution. From 1980 to 1994, for example, the proportion of Americans with asthma increased by 75 percent. In children under the age of five, the proportion grew by 160 percent (AAAAI 2005). The reason for their concern is asthma is the leading cause of school absenteeism and hospitalizations in children under the age of 15, accounting for an estimated 14 million lost school days and $16 billion in annual health care expenditures for both children and adults. Asthma also tends to be seasonal, especially among children, with a noticeable spike in asthma-related emergency room visits and hospitalizations in September (Johnston et al 2006, Neidell 2004, AAFA 2005, AAAAI 2005).

Researchers have clear evidence that the quality of indoor air is a factor. 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). Other studies also have found an association between VOCs and asthma in children (CARB 2005).

Two other studies provide the first solid evidence that damp buildings and exposure to mold bioaerosols is a risk factor for developing asthma and not just in making asthma symptoms worse. Jouni J.K. Jaakkola and his colleagues followed 1,984 children living is Espoo, Finland from birth for six years of age (1,916 children were included in the study results) and began before the children developed asthma (Jaakkola et al 2005). Jean M. Cox-Gasner and her colleagues followed 356 adults for a full year. The study participants worked in a multi-story office building, with a history of moisture problems and water intrusion (Cox-Gasner et al 2005).

The results of these two studies indicate that there is clear connection between damp buildings, associated indoor mold growth and the development of asthma. The risk for developing asthma appears higher for, but is not limited to, children who are sensitive to mold allergens or who have parents with asthma (Jaakkola et al 2005, Cox-Ganser et al 2005). For more information about these studies, see the AQS research report *Asthma and Damp Buildings: Making the Connection*, which is available free of charge from the Aerias AQS IAQ Resource Center under the Premium Content tab at **www.aerias.org**.

Educators, parents, physicians and pubic health officials also are concerned about an apparent increase in the number of children diagnosed with autism spectrum disorders (ASD) – and as with asthma wonder if there is a connection with exposure to indoor air contaminants. Estimates suggest that around 6 in 1,000 people in the world suffer from ASD, with more boys affected than girls. The increase in prevalence of ASD is partially due to changes in diagnostic criteria, terminology and increased reporting. Although there are as yet no conclusive links between autism and chemical exposure, a recent review of scientific literature on the causes of neurodevelopmental disorders implicated a number of industrial chemicals including lead, methylmercury, polychlorinated biphenyls, arsenic, and toluene (Grandjean and Landrigan 2006).

## What Can Be Done to Protect Children's Health Against Indoor Air Contaminants Particularly in Schools?

Given the significant impact of indoor air pollution on children's health, following the three basic principals of providing good indoor air quality is an excellent strategy for protecting children's health. These principals are adequate ventilation, source control and air filtration.

Although compliance with the American Society for Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) standards for ventilation rates may be the minimal acceptable standard for green schools, there is good evidence that increasing the ventilation rate beyond the ASHRAE standard will further improve comfort and productivity. However, an upper limit on the ventilation rates, indicating when the benefits of outside air begin to decline, has not been established (National Research Council 2006).

From a review of available research, the CARB report to the California Legislature also concluded that: "Epidemiological studies have often found significantly lower prevalence of respiratory illness or surrogates for respiratory illness (sick leave, total absence from school) in buildings with higher ventilation rates, reduced office sharing, and less crowding" (Fisk 2000, Myatt et al 2004, Shendell et al 2004).

In addition, the Jaakola and Cox-Gasner studies cited above support the premise that cleaning up and preventing indoor mold growth by eliminating moisture and water intrusion is a critical factor for reducing the number of people who develop asthma and the frequency and severity of attacks among those who do have asthma (Jaakola et al 2006, Cox-Gasner et al 2006).

Efforts to improve IAQ in schools are gaining momentum, due in part to the explosive growth in the number of children developing asthma and the increased interest in using environmentally friendly products and green (sustainable) building methods. At the federal level, the USEPA's Indoor Air Quality Tools for Schools program continues to lead the way in providing resources and programs for school districts, administrators, facility managers and teachers to improve the air quality in schools. At the state level, California has taken a lead role in raising awareness about the negative impacts of poor IAQ in schools and protecting students from indoor air pollution through its Collaborative for High Performance Schools (CHPS) program. To assist schools districts, the CHPS program has developed five Best Practices Manuals in design, construction, operation and maintenance. These manuals offer a non-regulatory approach that could yield large gains in indoor health in all types of buildings.

While other states and local jurisdictions are following suit, as are private education organizations. Among the guidance offered by these programs is to use environmentally friendly construction materials, furnishings, finishes, office equipment, and cleaning products and processes. To date, however, none of the available product standards and protocols that ensure low emission levels of VOCs has taken children's special needs into account – until now.

The GREENGUARD Environmental Institute (GEI) has created a new standard and product certification for low-emitting products and materials for use in daycare and school facilities. The tough GREENGUARD Certification for Children & Schools is an extension of the established GREENGUARD Indoor Air Quality Certification Program.

This standard takes the sensitive nature of school populations and the unique building characteristics and maintenance conditions found in schools into consideration and presents the most rigorous product emissions criteria to date. The following summarizes key provisions in the standard, requiring that all construction and furnishing products meet these emission levels within seven days of unpackaging and installation in the school. This standard limits acute (irritation and odor) and long-term chronic exposure effects (Table 3).

**Table 3. GREENGUARD Emission Standard for Educational Environments (see bullets following the table for important notes)**

| Chemical | **Allowed Emission Contributions** |
|---|---|
| TVOC | $\leq$ 215 µg/m$^3$ |
| Formaldehyde | $\leq$ 0.022 ppm |
| Total Aldehydes | $\leq$ 0.043 ppm |
| Individual VOCs | $\leq$ 1/100 TLV or ½ CA Chronic REL (whichever is less) |
| Total Phthalates | $\leq$ 10 µg/m$^3$ |
| Total Particles ($\leq$ 10µm) | $\leq$ 22 µg/m$^3$ |

Notes:

- Total phthalates include dibutyl (DBP), diethylhexyl (DEHD), diethyl phthalate (DEP), dibenzyl phthalate, (DBzP), diisobutyl phthalate (DIBP), and diethyl (DEP), common material related phthalates.
- Identified VOCs measured in mass spectrometric scan of $C_6$ - $C_{16}$ hydrocarbon range, evaluated for presence on ACGIH/TLV list and CA CREL list. TVOC includes all measured VOCs in scan range calibrated to toluene.
- Total aldehydes include 2-Butenal, Acetaldehyde, Benzaldehyde, Benzaldehyde 2,5-dimethyl, Benzaldehyde 2-methyl, Benzaldehyde 3- and/or 4-methyl, Butanal, Butanal 3-methyl, Formaldehyde, Hexanal, Pentanal, and Propanal.
- Particles applicable to fibrous, particle-releasing products with exposed surface area.

Visit us at at **www.aqs.com** to learn more about how the AQS Building Consulting Group and Product Evaluations team can help you, or call us at (770) 933-0638. Also visit the GREEENGUARD Environmental Institute at **www.greenguard.org** and the AQS Aerias IAQ Resource Center to learn more about particulates, VOCs and other indoor contaminants. Aerias may be accessed from the AQS website or at **www.aerias.org**.

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