



## Don't let your floors put a ceiling on your health.

How flooring affects indoor air quality.

**When it comes to our health and well-being, it is easy to forget about air as a potential risk factor because we can't really see it. But, a vast number of studies over the past 50 years have demonstrated that the quality of the air we are breathing is something to really consider.**

Air pollution is the single biggest environmental threat to human health according to the World Health Organization. Nine out of ten people in the world breathe polluted air, causing more than seven million premature deaths every year — double the number of people dying from HIV, malaria and tick-borne encephalitis combined<sup>1</sup>. In 2015 diseases of the respiratory system accounted for 7.7 % of all deaths in the EU<sup>2</sup>.

Much progress has been made in Europe in improving outdoor air quality.

However, one commonly overlooked fact is that we spend on average 93% of our time indoors<sup>3</sup>, be it at home, in school, the office, or other public buildings. This is of significant importance, because the concentrations of

some pollutants are often 2 to 5 times higher than typical outdoor concentrations. While 3 million of the abovementioned premature deaths are caused by outdoor air pollution-related diseases, more than 4 million are caused by indoor air pollution.

Indoor air quality (IAQ) is the relative measure of harmful pollutants that can be found in the air of an indoor environment<sup>4</sup>. These pollutants can include anything from gases such as carbon monoxide to microbial contaminants such as mold or bacteria. Indoor air may contain over 900 chemicals, particles and biological materials with potential detrimental health effects<sup>5</sup>.

**9 out of 10 people in the world breathe polluted air**

**Causing 7,000,000 premature deaths**

**Which is 7.7% of all deaths in the EU**

IAQ is affected by a variety of factors. Of course climate and outdoor environment, ventilation, cleaning conditions and products used in households all influence IAQ. However building materials used, particularly in flooring and walls, also play

an important part. These can emit airborne particulates and volatile organic compounds that may be harmful to the building's occupants.

**1900** Chemicals, Biologicals & Particles

<sup>1</sup> <https://www.ft.com/content/dc088e34-1577-11e8-9376-4a6390addb44>

<sup>2</sup> [http://ec.europa.eu/eurostat/statistics-explained/index.php/Respiratory\\_diseases\\_statistics](http://ec.europa.eu/eurostat/statistics-explained/index.php/Respiratory_diseases_statistics)

<sup>3</sup> <https://cfpub.epa.gov/roe/chapter/air/indoorair.cfm>

<sup>4</sup> <http://www.tarkettsportsindoor.com/en/sports-flooring-guide/indoor-air-quality>

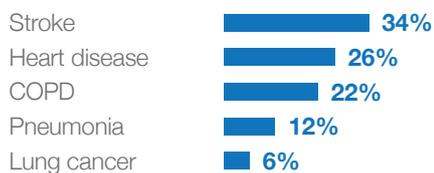
<sup>5</sup> <http://copublications.greenfacts.org/en/indoor-air-pollution/index.htm#1>



## THE AIR WE BREATHE

**Prolonged exposure to high levels of air pollution can affect human respiratory and inflammatory systems. Poor IAQ not only causes headaches and dizziness, it can also exacerbate asthma and allergies. Furthermore it can lead to increased mortality from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections<sup>6</sup>. Especially children, pregnant women and the elderly are highly susceptible to negative effects from air pollution.**

Of the 4 million premature deaths each year from exposure to household air pollutants, the causes are divided as follows:



**30 million** Asthma is the commonest chronic disease in childhood. According to 2017 European statistics, about 30 million children (8% of all schoolchildren) and adults



less than 45 years old have asthma<sup>7</sup>. 85% of European pupils are exposed to too high amounts of fine dust, 50% are exposed to excessive amounts of radon and 25% are exposed to too much benzene<sup>8</sup>. Moreover, 60% of children are also exposed to high levels of formaldehyde and carbon dioxide within school grounds.

Asthma is a chronic inflammatory disease of the airways that causes recurring episodes of wheezing, breathlessness, chest tightness and coughing. It is a common disease that affects people of all ages

throughout Europe. Most commonly it arises in childhood and may persist into adulthood. In two-thirds of children with asthma, the disease remits in the early teenage years, only to relapse in adulthood in about a third of these cases<sup>9</sup>. According to the same EU study mentioned above, 8% of pupils suffer from asthma, 9% of nasal allergies and 17% of eczema. Of those children suffering from asthma, 3.6% had an asthma attack at school.

Asthma results from an interaction between different environmental and genetic factors. Susceptibility to asthma is genetically predetermined but the sharp rise in the prevalence during childhood indicates important environmental determinants acting on this genetically susceptible population<sup>10</sup>. The distribution of the disease suggests a strong association and link with our 'Western' environment, possibly reflective of urbanization and our tendency to spend ever more time indoors. This is backed by the fact that exacerbations of asthma are especially common in winter and shortly after the return of children to school after the summer holiday.

Kindergartens and schools are the environments where children spend the majority of their time, and the need for a healthy indoor environment in such institutions should be emphasized. Hence in schools, additional precautions should be taken to reduce allergen exposure for asthmatic children.

## SICK BUILDING SYNDROME

**In most cases asthmatic symptoms subside during young adulthood, but the fact remains that about 35% of people relapse during adulthood, again suggesting a strong link to poor IAQ in the workplace environment.**

<sup>6</sup> <http://www.tarkettsportsindoor.com/en/sports-flooring-guide/indoor-air-quality>

<sup>9</sup> <https://www.erswhitebook.org/chapters/adult-asthma>

<sup>10</sup> <https://www.erswhitebook.org/chapters/adult-asthma>

<sup>7</sup> <https://www.erswhitebook.org/chapters/adult-asthma>

<sup>8</sup> <https://www.pure-air-zone.com/single-post/2017/10/26/EU-research-on-Air-quality-in-schools-says-children-are-at-risk>

<http://www.e-gezondheid.be/het-sick-building-syndrome/actueel/1165>

<https://mens-en-gezondheid.infonu.nl/aandoeningen/101550-oorzaken-en-symptomen-sick-building-syndrome.html>

The term Sick Building Syndrome (SBS) is used to describe situations where people experience negative health effects from spending time in a home or building<sup>11</sup>. The syndrome was first described and reported during the 1970s among employees working in brand-new office buildings. The affliction was officially acknowledged in 1984, when the WHO published the first report mentioning SBS as a real and valid disease caused by well-determined and clear causes, namely poor IAQ<sup>12</sup>. During the oil crisis that dominated the seventies, energy became a high-priced commodity and people sought a way to decrease heating costs and hence make new buildings as energy-efficient as possible. This led to newly built and renovated schools, offices and houses, being designed to be as hermetically sealed as possible. Although this assumption was true, as these buildings required less heating and were hence more energy-efficient, that way of designing and building structures also caused substantial negative side effects. Indeed, the new buildings were efficient at keeping cold air out, but unfortunately also very efficient at trapping bacteria, molds and other pollutants inside.

Ever since studies have also demonstrated SBS to be prevalent in i.a. hospitals and schools. A common characteristic of SBS is that it never affects just one person, but instead groups of people, i.e. employees working – or people residing in – the same building. Symptoms range from relatively harmless to more severe, include among others: headaches, severe fatigue, irritability, problems concentrating, dizziness, nausea, irritation of the eyes, colds, tight feeling in the chest area, all the way up to more severe and frequent respiratory infections, causing absenteeism and burn-outs.

Research has shown up to 80% of employees affected by SBS. Scientists have identified a number of clear biological factors that contribute to SBS, mainly the presence of microorganisms (microbes) and molds, as well as chemical factors such as ozone gas, components emitted from paper, wooden, and other building materials, and phthalates. The latter are industrial chemical substances added to e.g. PVC plastics in order to make them more pliable, or are found in building materials such as vinyl flooring and solvents<sup>13</sup> which emit particulates that are subsequently aspired by the building's occupants.

The most effective remedy against SBS consists of reducing or eliminating the risk factors. Reducing risks can be done by increasing ventilation, regular and thorough cleaning of floors and furniture, and keeping the ambient temperature low. However eliminating risks requires a more structural approach, i.e. avoiding building materials that emit harmful chemical components.



Research into SBS has demonstrated a clear and unambiguous link with poor IAQ. The indoor oxygen level decreases due to microscopic dust and airborne particulates exponentially multiplying. These allergens multiply at considerable speed. In dry air environments that are insufficiently ventilated allergens multiply by 20 each and every day. In damp indoor environments this number even increases to 60<sup>14</sup>.

<http://www.milieu-en-gezondheid.be/sites/default/files/atoms/files/weekmakers-ftalaten.pdf>

<http://www.envirotec.be/op-het-werk/sick-building-syndrome-oorzaken/>

## AN INSIDE JOB

**As stated at the top of this paper air pollution, both indoors and outdoors, is currently one of the major European and worldwide health concerns. A lot of attention so far has gone to outdoor air quality and limiting several pollutants. However, IAQ requires at least the same amount of attention because this is where we spend most of our time. The goal of the EU air policy is to achieve levels of air quality that do not result in unacceptable risks to human health.**

Indoor exposure to air pollutants may occur in both private and public indoor environments such as homes, offices, schools and transport systems. Although some indoor air pollutants come from the outside, most are released inside the building, for example when cleaning. Certain construction materials can also emit pollutants. Dampness and lack of ventilation may further exacerbate poor IAQ<sup>15</sup>.

Climate change and ever-increasing energy costs have an impact on IAQ as well. For example, extreme weather conditions may increase the need for additional insulation and decreased ventilation, which may lead to too high or too low indoor temperatures or to humidity problems. The main determining factors influencing IAQ are listed below.



## Volatile organic compounds

**Two common causes of complaints associated with poor IAQ are bad smells and irritation of the eyes, nose and throat<sup>16</sup>. Such irritation is usually induced by specific chemicals, with a common worsening effect due to dry indoor air. Bad smells are unpleasant but not**

**harmful in themselves. They can however lead to more severe symptoms such as headaches, nausea, and irritation of eyes or throat.**

The main culprits of these unpleasant and/or harmful effects are volatile organic compounds (VOCs). These are organic chemicals that evaporate at low ambient room temperature and are easily dispersed into the surrounding air<sup>17</sup>.

VOCs include both human-made and naturally occurring chemical compounds. Some of which may furthermore cause short- and long-term adverse health effects. Concentrations of VOCs are commonly up to ten times higher than outdoors<sup>18</sup>. VOCs are emitted by a wide array of products:

- A major source of man-made VOCs are coatings, especially **paints and protective coatings**<sup>19</sup>. These solvents are required to apply a protective or decorative film.
- Another source of VOCs is benzene. It is frequently used in **the production of plastics, resins and synthetic fibers**. Benzene evaporates into the air quickly and has also been known to contaminate food and water, possibly leading to serious illness if ingested<sup>20</sup>.
- **Methylene chloride** can be found in **adhesive removers and aerosol spray paints**. In the human body, methylene chloride is metabolized to carbon monoxide<sup>21</sup>.
- **Formaldehyde** is slowly emitted from building materials such as **paints, adhesives, wall boards, and ceiling tiles**. The compound irritates the mucous membranes and can make a person irritated and uncomfortable<sup>22</sup>. High humidity and high temperatures allow more vaporization of formaldehyde from wooden materials.

## Radon

Radon, which occurs naturally in parts of Europe and the rest of the world, is a radioactive gas emitted by uranium in soil and rocks. It is a clear, odorless and tasteless gas and hence unperceivable when present in buildings<sup>23</sup>. Radiation

<sup>15</sup> [http://ec.europa.eu/health/scientific\\_committees/opinions\\_layman/en/indoor-air-pollution/index.htm#11](http://ec.europa.eu/health/scientific_committees/opinions_layman/en/indoor-air-pollution/index.htm#11)

<sup>16</sup> <https://mens-en-gezondheid.infonu.nl/aandoeningen/101550-corzaken-en-symptomen-sick-building-syndrome.html>

<sup>17</sup> [https://en.wikipedia.org/wiki/Volatile\\_organic\\_compound](https://en.wikipedia.org/wiki/Volatile_organic_compound)

<sup>18</sup> <https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality>

<sup>19</sup> [https://en.wikipedia.org/wiki/Volatile\\_organic\\_compound#Paints\\_and\\_coatings](https://en.wikipedia.org/wiki/Volatile_organic_compound#Paints_and_coatings)

<sup>20</sup> <https://en.wikipedia.org/wiki/Benzene>

<sup>21</sup> [https://en.wikipedia.org/wiki/Methylene\\_chloride](https://en.wikipedia.org/wiki/Methylene_chloride)

<sup>22</sup> <https://en.wikipedia.org/wiki/Formaldehyde>

<sup>23</sup> <http://www.gezondheidsmilieu.be/nl/subthemas/radon-2740.html>



from inhaled radon and long-lived radon decay products may damage lung tissue, which can lead to lung cancer after prolonged exposure. It's the second leading cause of lung cancer, besides smoking. In an outdoor environment radon is quickly dispersed into the atmosphere and thus quite harmless. Indoors however it can accumulate in insufficiently ventilated rooms. Other influencing factors of radon concentrations consist of the surrounding area in itself, the underlying soil and the building materials used.

### Suspended particles

Coarse, fine and ultrafine particles in ambient air are known to cause adverse health effects, particularly on the respiratory and cardiovascular systems<sup>24</sup>. These particles may come from outdoor pollution, but can also form indoors by reactions between ozone and some VOCs, and by the burning of fuels for heating and cooking. In addition, man-made nanoparticles, which are increasingly used in consumer products, may also impact indoor air pollutants.

### Microbes

Microorganisms such as fungi and viruses are especially problematic in damp buildings or indoor environments because these cause mold and because many fungi release substances that cause allergies<sup>25</sup>. Viral infections may also be transmitted by indoor air and some of them can lead to an increase in asthma and allergies.

### Humidity

Dampness or moisture may accumulate in the building structures or finishing materials via leaks in roofs, windows or piping. Dampness and mold increase risk of asthma-related problems by 30-50%. Good IAQ requires an optimal level of humidity. Too low humidity causes eye irritation, dry skin, and rashes, whereas too high humidity results in water damage and mold problems, and favors the growth of dust mites<sup>26</sup>.

### Ventilation

Ventilation is one of the most important factors determining IAQ. Poorly ventilated offices and schools can affect health and work or academic performance. Adequate ventilation is especially needed in heavily insulated buildings that allow little air exchange with the outside.

### Temperature

In addition to ventilation, proper ambient temperature is also one of the basic requirements for good IAQ. Extreme indoor temperatures are a serious health hazard. Indoor air that is very cold or hot is highly unhealthy. Air that is too warm, for example, aggravates the effects of insufficient humidity<sup>27</sup>.

### Lead

The use of lead-containing indoor paints has been banned or restricted for quite some time now. However, some old houses in parts of the EU still have paintwork containing lead. Even low-level exposure to lead is harmful for children, for whom the main route of exposure is swallowing dust<sup>28</sup>.

<sup>24</sup> [http://ec.europa.eu/health/scientific\\_committees/opinions\\_layman/en/indoor-air-pollution/1-2/2-determining-factors.htm#0](http://ec.europa.eu/health/scientific_committees/opinions_layman/en/indoor-air-pollution/1-2/2-determining-factors.htm#0)

<sup>26</sup> [http://ec.europa.eu/health/scientific\\_committees/opinions\\_layman/en/indoor-air-pollution/1-2/2-determining-factors.htm#0](http://ec.europa.eu/health/scientific_committees/opinions_layman/en/indoor-air-pollution/1-2/2-determining-factors.htm#0)

<sup>25</sup> [http://ec.europa.eu/health/scientific\\_committees/opinions\\_layman/en/indoor-air-pollution/1-2/2-determining-factors.htm#0](http://ec.europa.eu/health/scientific_committees/opinions_layman/en/indoor-air-pollution/1-2/2-determining-factors.htm#0)

<sup>27</sup> [http://ec.europa.eu/health/scientific\\_committees/opinions\\_layman/en/indoor-air-pollution/1-3/2-determining-factors.htm#0p0](http://ec.europa.eu/health/scientific_committees/opinions_layman/en/indoor-air-pollution/1-3/2-determining-factors.htm#0p0)

<sup>28</sup> [http://ec.europa.eu/health/scientific\\_committees/opinions\\_layman/en/indoor-air-pollution/1-2/6-harmful-chemicals.htm#0](http://ec.europa.eu/health/scientific_committees/opinions_layman/en/indoor-air-pollution/1-2/6-harmful-chemicals.htm#0)

## BETTER SAFE THAN SORRY

[http://www.europeanlung.org/assets/files/publications/lung\\_health\\_in\\_europe\\_facts\\_and\\_figures\\_web.pdf](http://www.europeanlung.org/assets/files/publications/lung_health_in_europe_facts_and_figures_web.pdf)

**According to the European Lung Foundation<sup>29</sup> 1 in 8 deaths in the EU are from respiratory diseases, totaling 600,000 people who die every year in the EU from respiratory disease. 6 million hospital admissions per year are due to respiratory diseases. Indoor air pollution is the 8th most important risk factor for disease and is responsible for an estimated 2.7% of the global burden of all diseases in the EU, linking between 1.5 million and 2 million deaths a year to indoor air pollution. The total cost of respiratory disease in the EU exceeds 380 billion euro.**

These are staggering numbers, and that is why the EU is vying for the tightening of building material standards to avoid worsening IAQ, and reducing indoor air pollutants putting workers at risk.

Exposure to household air pollution, as well as poor air quality in offices and public buildings can lead to a wide range of health problems. These can range anywhere from short-term to long-term effects, and can even result in death<sup>30</sup>.

<http://www.timesnownews.com/health/article/health-effects-of-indoor-air-pollution-this-is-how-poor-indoor-air-quality-affects-your-health/202711>

SHORT-TERM	LONG-TERM
Eye Irritation	(Worsening) Asthma
Pharyngitis (throat irritation)	Chronic obstructive pulmonary disease
Coughing	Lung cancer
Headache	Ischemic heart disease
Dizziness	Stroke
Wheezing	Cataract
Nasal congestion (inflammation of the nose)	Dyspnea ( strenuous or painful breathing)
Fatigue	Muscle pain
Nausea, vomiting	Hearing loss

One very important thing to consider when taking into account all of the above health risks, is that certain people are considerably more vulnerable than others to indoor air pollution. These include children, pregnant

women, people over 65 years of age, and persons suffering from cardiovascular and respiratory diseases (e.g. asthma). Other factors that may render some people more vulnerable

are genetic traits, lifestyle, nutrition and – for some pollutants – other health problems (e.g. immunodeficiency)<sup>31</sup>.

Depending on their age and the type of chemical or airborne particulates to which they are exposed, children may be more vulnerable than adults to certain toxic substances

(e.g. lead). This is due to a variety of reasons: their lungs are still growing and developing, their immune and metabolic systems are still developing, they suffer from frequent respiratory infections, and they are more active outdoors than adults and therefore breathe in higher doses of outdoor pollutants<sup>32</sup>. Vulnerability to chemical toxicity after birth is highest during the first 6 months and continues for years before maturation<sup>33</sup>.

The negative effect on child lung development has been observed at a much lower concentration level of toxins at which no adverse effects were observed in adults, which suggests that children are more vulnerable than adults. In addition, air pollutants may cause cough, bronchitis and other respiratory diseases, and make asthma worse. Particulate matter, nitrogen dioxide and ozone have been identified as important causes. Young children are also at risk of higher exposure due to specific behavioral patterns (e.g. hand-to-mouth activity). In pregnant women exposure of unborn

<http://www.health.nsw.gov.au/environment/air/Pages/who-is-affected.aspx>

<https://copublications.greenfacts.org/en/indoor-air-pollution/1-3/4-vulnerable-groups.htm>

**600,000 people in the EU die from respiratory disease every year, which amounts to 1 in 8 deaths**

[https://ec.europa.eu/health/scientific\\_committees/consultations/public\\_consultations/scher\\_cons\\_01\\_en](https://ec.europa.eu/health/scientific_committees/consultations/public_consultations/scher_cons_01_en)

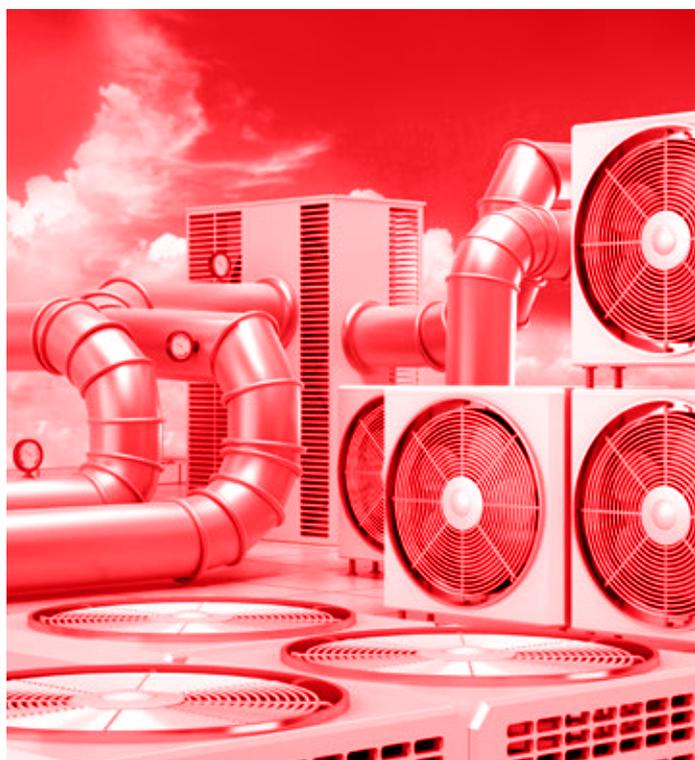
<http://www.health.nsw.gov.au/environment/air/Pages/who-is-affected.aspx>

babies to high levels of air pollution over longer periods of time may cause adverse pregnancy outcomes such as reduced birth weight or preterm birth<sup>34</sup>.

Elderly people are at an increased risk of developing the abovementioned health issues and are particularly vulnerable to air pollution because the ability to eliminate chemicals from the body decreases with age.

Persons suffering from cardiovascular diseases are more vulnerable to particles and those suffering from respiratory diseases such as asthma are more vulnerable to several air pollutants. In people with asthma exposure to air pollution might worsen symptoms or trigger asthma attacks. People with lung disease, such as chronic bronchitis (also called chronic obstructive pulmonary disease or COPD), may suffer from worsening symptoms when exposed to air pollution. People suffering from cardiovascular (heart) disease might experience e.g. symptoms such as palpitations, chest pain or shortness of breath when exposed to air pollution<sup>35</sup>.

<http://www.health.nsw.gov.au/environment/air/Pages/who-is-affected.aspx>



The fact that not only these vulnerable groups, but in fact all people, spend the majority of their time indoors warrants an across-the-board general strategy and approach to reducing adverse effects caused

by poor air quality. These measures can range anywhere from structural measures such as correct building materials and flooring choices, to temporary measures such as eliminating or reducing sources of toxins and increasing ventilation.

### Preventing the entry of pollutants from outside the building<sup>36</sup>:

- This can be achieved by e.g. installing radon barriers and by sealing cracks and openings, including the joints where the floor meets the wall, openings in the floor for the passage of pipes and wires, and hollow masonry walls that penetrate the floor.
- Ventilating the entire building on regular intervals, especially the basement as well as any crawlspaces.
- Placing entry mat systems critical in trapping soil, pollutants, and moisture that otherwise would spread into and throughout the building.

<https://www.epa.gov/iaq-schools/controlling-pollutants-and-sources-indoor-air-quality-design-tools-schools#VentilationTechniques>

### Reducing exposure to biological contaminants<sup>37</sup>:

- Install and use exhaust fans that are vented to the outdoors in kitchens and bathrooms.
- Ventilate the attic and crawl spaces to prevent moisture build-up.
- Thoroughly clean and dry water-damaged carpets and building materials (within 24 hours if possible) or consider removal and replacement.
- Regular cleaning will reduce house dust mites, pollens, animal dander and other allergy-causing agents.

[https://www.epa.gov/indoor-air-quality-iaq/biological-pollutants-impact-indoor-air-quality#Reducing\\_Exposure](https://www.epa.gov/indoor-air-quality-iaq/biological-pollutants-impact-indoor-air-quality#Reducing_Exposure)

### Reducing or eliminating the emission of VOCs<sup>38</sup>:

- Increase ventilation when using products that emit VOCs.
- Do not store products containing formaldehyde or benzene such as paint strippers, adhesive removers and aerosol spray paints, and only use them outdoors when possible; or indoors only if the area is well ventilated.

<https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality#Steps>

- Many building materials such as wood, paints, adhesives, and wall boards slowly emit low amounts of formaldehyde, which can be counteracted by lowering humidity and temperature.
- Use low-VOC or no-VOC paint and other products when decorating.

Contrary to the reactive and temporary measures above, the only permanent long-term solution to optimize IAQ and maintain healthy indoor living conditions however consists of making smart and well-informed decisions when it comes to choosing building materials and flooring for your home, office, or school building.

## NOT ALL FLOORS ARE CREATED EQUAL

**To protect indoor environmental quality one should first and foremost seek to eliminate any and all potential sources of contamination that originate from flooring and other building materials. This means selecting low-toxicity, low-(VOC)-emitting, moisture-resistant materials that can be safely installed and maintained. Safe and healthy options for flooring and other materials are indexed and supervised by independent international regulators (see later).**

When selecting materials for interior surfaces one should look for cost-effective, durable and materials-efficient products that provide the desired performance and maintain good IAQ. Interior building materials important from an IAQ point of view include carpets, paints, sealants and caulking, adhesives, floor and ceiling tiles, molding, and wood products. The contaminants contained within these products are gradually emitted throughout the material's lifecycle. These contaminants include predominantly VOCs and small particulate substances that act as eye or throat irritants<sup>39</sup>.

<https://www.epa.gov/iaq-schools/controlling-pollutants-and-sources-indoor-air-quality-design-tools-schools>  
#PreventingtheEntryofPollutants

Of the utmost importance when determining strategies and processes for materials selection, is to firstly only use products that feature consensus standards. Select only products based on available consensus standards which are developed and monitored by government agencies, environmental certification services, or trade organizations. These certificates address health and toxicity issues relating to specific material types. Secondly one should prioritize sensitive areas from a health-related point of view. Identify and prioritize spaces where material selection issues are of particular concern based on intended occupancy and activities, such as healthcare facilities, schools, gymnasiums, and so forth.

The two most commonly used floor types for general use are carpet and resilient flooring. Carpet offers acoustical and comfort benefits that are generally not available with other floor coverings. Resilient flooring is commonly used for high-traffic areas. While there are advantages and disadvantages to any flooring choice, regular and effective cleaning and maintenance is essential in keeping floors dry and clean, thus avoiding soil, pollutants, and moisture from accumulating and subsequently spreading throughout the building.

### Resilient flooring

The impact of resilient flooring on IAQ varies by flooring material, installation method, and maintenance procedures. The Resilient Floor Covering Institute (RFCI), in collaboration with Scientific Certification Systems (SCS), has developed the FloorScore® IAQ



Certification Program. This is a voluntary, independent certification program that tests and certifies hard surface flooring for compliance with the indoor air emissions of VOC criteria (see later).

Resilient flooring offers numerous benefits that other flooring categories just can't match<sup>40</sup>. Resilient flooring, or vinyl flooring, as some call it, is an engineered product. One of the prime benefits of resilient flooring is that it provides exceptional performance in high-traffic areas. The flooring is extremely resistant to scratching, stains and scuffs, caused by every-day wear and tear.

Other advantages of resilient floors are their considerable ease of maintenance. They provide a smooth surface free from cracks and crevices, allowing for quick and easy cleanup of dirt, dust

and mess on the one hand, and reducing the accumulation of harmful bacteria and pollutants on the other hand. Resilient flooring is also moisture-resistant, meaning it is the perfect product for i.a. kitchens or bathrooms<sup>41</sup>.

Resilient flooring also absorbs sound, which provides a quieter and more peaceful living space. It's warmer to the touch, so provides a more pleasant feeling early in the morning or during the cold winter months. It's beneficial for joint and back aches as well, when standing for prolonged periods of time.

### If resilient flooring is your choice of flooring, select a floor that:

- has been tested and is compliant with country-bound regulations and eco labels with regards to VOC emissions;
- can be easily cleaned and maintained with low-VOC cleaners and finishes;
- can be installed with an adhesive-free click-and-lock system or is self-adhesive (pressure-sensitive adhesive on the back of the flooring panels).;
- uses high-performance coatings to reduce maintenance costs and use of cleaners and floor finishes.

### Carpet

The Carpet and Rug Institute (CRI) has developed the CRI IAQ Green Label Program (CRI "Green Label") to determine the level of VOC emissions from carpets and floor adhesives. The CRI Green Label attached to a carpet or floor adhesive signifies that a representative sample of the product type has been tested by an independent laboratory (see later) and meets the requirements for each program established by CRI<sup>42</sup>.

Carpet may act as a reservoir for dust, dirt, pollen, mold spores, pesticides and other materials which may originate indoors or be brought into the indoor environment from outside. If kept very clean from the time it is installed, a significant amount of these particles can be removed through regular and effective vacuuming.

<sup>40</sup> <https://www.congoleum.com/benefits-of-resilient/>

**FloorScore® is a voluntary, independent certification program testing hard surface flooring for compliance with indoor air emissions criteria.**

<sup>41</sup> <https://www.congoleum.com/benefits-of-resilient/>

<sup>42</sup> <https://www.epa.gov/iaq-schools/controlling-pollutants-and-sources-indoor-air-quality-design-tools-schools#Carpet>



Moisture trapped below a carpet can result in mold growth and the release of mold spores into indoor air. Effective moisture control is hence critical to protect the entire building. Additionally it is essential that concrete be sufficiently cured and dried before carpet is installed over it.

**If carpet is your choice of flooring material, be sure to select carpet that:**

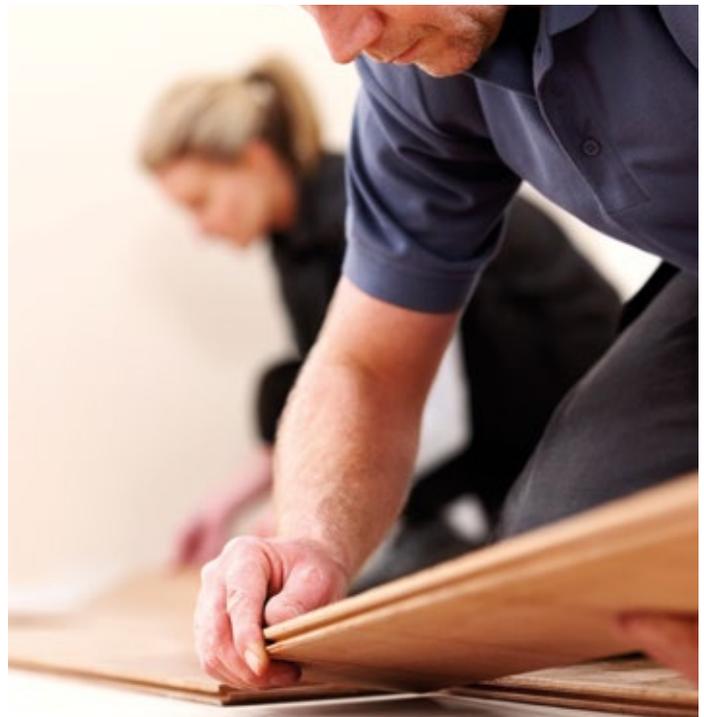
- has been tested and is compliant with country-bound regulations and eco labels with regards to VOC emissions;
- can be easily cleaned and maintained;
- is specifically manufactured to prevent liquids from penetrating the backing layer;
- can be installed with low-VOC adhesive or by way of an adhesive-free free-floating system;
- can be easily removed without the use of toxic chemicals;
- is unrolled and aired out by the supplier in a clean, dry warehouse before installing it.

**Wood flooring**

For those with environmental concerns, wood flooring can be very attractive, especially if the wood comes from sustainably managed forests or recycled wood. Some of the drawbacks of wood however is that it is more expensive than vinyl and must be periodically refinished to keep it looking good<sup>43</sup>. While new water-based polyurethane varnishes are available, most varnishes and other floor finishes still give off large quantities of VOCs into the air. Wood flooring may also emit formaldehyde if laminates are placed on pressed wood underlayments. Barrier coatings and sealants should hence be used to encapsulate the components and to reduce formaldehyde emissions.

**If wood is your choice of flooring, select a floor that:**

- contains formaldehyde-free engineered wood products that are certified by independent, objective third-party regulators.



**Walls and ceiling materials**

Wall and ceiling systems are used for a variety of purposes, such as acoustical sound dampening, modular wall panels, suspended ceiling tiles, and surface-mounted ceiling and wall panels. Because of the large ceiling surface area, the likelihood of its contact and impact on ventilation systems is important to consider when it comes to air quality and materials efficiency.

**Take the following into consideration<sup>44</sup>:**

- Select formaldehyde- and asbestos-free options;
- Sequence work to avoid applying VOC-containing materials in spaces with exposed acoustical surfaces;
- Ensure adequate ventilation during installation;
- Remove any wet ceiling tiles immediately to avoid mold contamination.

<sup>44</sup> <https://www.epa.gov/iaq-schools/controlling-pollutants-and-sources-indoor-air-quality-design-tools-schools#WallsandCeilingMaterials>

<sup>43</sup> <http://www.eng-forum.com/articles/flooring/flooring%20iaq.htm>



## Adhesives

Pressure-sensitive adhesives (PSAs) are used in a wide array of applications, ranging from floors and construction materials, to labeling and packaging, mounting graphics displays, and assembling electronic devices<sup>45</sup>.

<https://www.adhesivesmag.com/articles/88511-pressure-sensitive-adhesives-101>

PSAs hold two surfaces together solely by surface contact, which is achieved by slight initial external pressure. These dry adhesives require no activation with water, solvent or heat, and firmly adhere to many dissimilar surfaces with minimal pressure. PSAs can be used for bonding materials such as plastic, paper, metal, glass, and wood.

**As far as choices for adhesives go, PSAs offer a variety of benefits compared to other alternatives, be it glue-down, click-and-lock, or free-floating installation methods:**

### Easy

- Ease of installation, by way of peel-and-stick installation;
- DIY-friendly, making specific skills and tool sets redundant;
- Permanent, removable and repositionable options.

### Fast

- Time-and-cost efficient;
- Fast installation, reducing installers' exposure to harmful substances;
- No cure time required, reducing downtime.

## Sustainable

- Lower in VOC emission compared to liquid adhesives, resulting in less exposure to harmful substances throughout the value chain;
- Sustainable raw material usage, reducing waste for landfills;
- Reduced exposure to harmful substances:
- Good performance with regards to moisture and temperature;
- Tear- and moisture-resistant.

## Paints, coatings, and sealants

Most conventional paint and coating products contain and disperse VOCs that are either added to the paint to enhance product performance and shelf life, or are caused as byproducts of the paint drying. In similar fashion, many conventional construction sealants, caulking, grouts, and mortars used to bond structural components are solvent-based and may off-gas large amounts of VOCs<sup>46</sup>.

<https://www.epa.gov/iaq-schools/controlling-pollutants-and-sources-indoor-air-quality-design-tools-schools>  
#AdhesivesandSealants

High-quality, low-toxicity, no- or low-VOC paint and coating products are widely available, and minimize the indoor air pollution load and may reduce any health risks to both workers and occupants<sup>47</sup>. Water-based acrylic latex paints are generally lower in VOCs than solvent-based paints. The former are generally safer to handle and easier to clean up as well, reducing health risks to workers and minimizing hazardous waste.

<https://www.epa.gov/iaq-schools/controlling-pollutants-and-sources-indoor-air-quality-design-tools-schools>  
#PaintsandCoatings

**Take the following into consideration<sup>48</sup>:**

- Choose low- or non-toxic, formaldehyde-free, zero- or low-VOC options, that meet durability and other performance requirements;
- Choose products without lead, mercury, chromium or cadmium;
- Where possible, perform painting and stripping off-site or schedule painting during unoccupied periods;
- Cover surfaces with plastic sheeting while painting, thus adsorbing VOCs;
- Wipe down all surfaces with a damp cloth after completing all dust-generating work;
- Keep paint containers covered as much as possible during and following use to protect against VOC release.



**SETTING THE STANDARD**

**Because of the vast importance of tackling these health issues various obligatory and voluntary national and international measurement standards have been developed for IAQ. These standards set out minimum and maximum values that need to be met by relevant product manufacturers, which in turn are tested and monitored by accredited third-party laboratories.**

This system of independent regular testing and auditing of various indoor building materials allows manufacturers to communicate their product's IAQ performance through labels and marks issued by these laboratories. The standards that need to be met by building materials are independently and objectively researched and determined, and hence provide complete transparency and credibility for manufacturers making claims regarding IAQ effects of their products. This means that consumers can be assured that products featuring such labels and marks are consistently meeting the performance requirements of the preset standards<sup>49</sup>.

[https://www.scsglobalservices.com/files/program\\_documents/scs\\_stn\\_ec10.3-2014\\_v4.0\\_031617.pdf](https://www.scsglobalservices.com/files/program_documents/scs_stn_ec10.3-2014_v4.0_031617.pdf)

Eurofins is an international group headquartered in Brussels, providing testing and support services to i.a. consumer products industries and to governments. Via their worldwide network of independent laboratories they carry out standardized tests of building material samples, within the context of country-bound IAQ regulations and labels such as e.g. Indoor Air Comfort Gold<sup>®</sup>. One very important certification to mention is FloorScore<sup>®</sup>. This is an IAQ certification issued by the Resilient Floor Covering Institute (RFCI), an industry trade association of resilient flooring manufacturers and suppliers of raw materials, additives, and various flooring products for the North American market.

**IAQ regulations entail compliance with the following: supervision at all stages of manufacturing, maintenance of a documented quality control plan, and regular on-site audits and yearly testing of representative samples by independent auditing authorities.**

The accreditation procedures cover the following floors and materials:

- Flooring adhesives;
- Vinyl flooring;
- Hardwood flooring;
- Laminate flooring;
- Linoleum flooring;
- Polymeric flooring;
- Rubber flooring;

Flooring accessories (e.g. underlayments, nosings, stair treads, etc).

**Manufacturers seeking IAQ product certification must comply at minimum with the following general requirements<sup>50</sup>:**

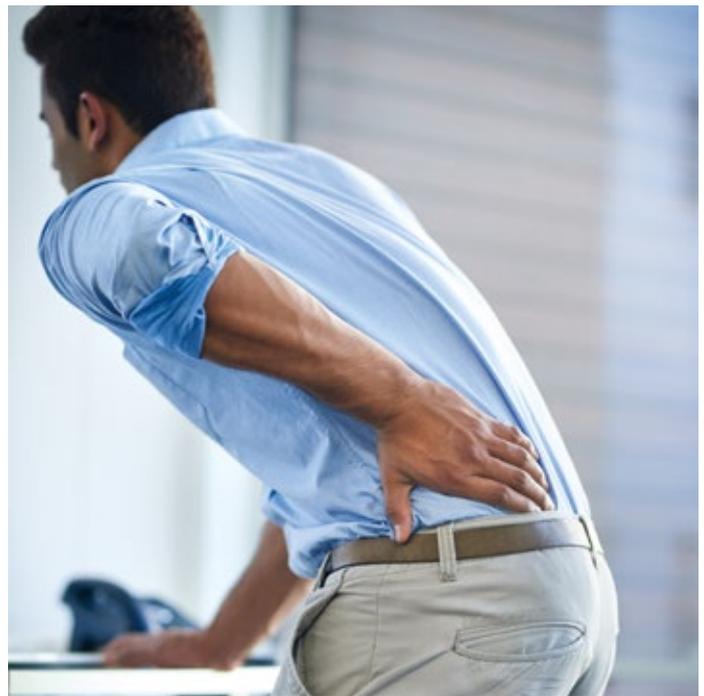
- Adequate supervision and control shall be exercised at all stages of manufacturing.
- Representative samples with the highest VOC emission potential (the worst-case representative product) shall be collected and sent to the independent auditing authorities.
- Manufacturers will only use independent ISO-accredited and SCS-approved laboratories with no direct connection to the manufacturer or otherwise potential conflict of interest.
- When determining VOC emissions, compliance of products to the standards shall be determined by comparing the calculated emission concentration to the applicable VOC emission criteria by using a steady-state, mass-balance model and standardized building scenario inputs.
- Manufacturers shall have a documented quality control plan for the production of the building products. This plan must guarantee adequate supervision and control to be exercised at all stages of the manufacturing operation.
- On-site audits of the manufacturing operation shall be conducted by an SCS-designated representative on a regular basis.

All IAQ certifications are valid for a period of one year. The certificate may be renewed annually for an additional one year period upon successful completion of a renewal assessment.

## DON'T SLIP UP

**Although IAQ is by far the biggest threat to our health, the structural integrity and proper maintenance of floors also factors in when trying to avoid accidents. The Occupational Safety and Health Administration (OSHA) has outlined clear safety regulations, requiring employers to maintain floors in optimal condition<sup>51</sup>.**

<sup>51</sup> <https://www.cleanlink.com/hs/article/OSHA-Regulations-On-Floor-Safety--17740>



Slips, trips and falls are the largest cause of work-related accidents across all sectors, ranging from heavy manufacturing to office work. In the EU these types of accidents have been identified as the main causes of accidents that result in more than 3 days absence from work<sup>52</sup>.

<sup>52</sup> <https://osha.europa.eu/en/publications/factsheets/14/view>

European Directives require employers to ensure that workplace floors are fixed, stable and level, have no bumps, holes or slopes, and are not slippery. The first aim should be to eliminate the source of any possible risks (e.g. levelling uneven floor surfaces). The next preferred option is substitution (e.g. using an alternative method of floor cleaning), followed by separation (e.g. using barriers to keep workers away from wet floors). The final prevention measure is protection (e.g. wearing footwear with non-slip soles).

<sup>50</sup> [https://www.scsglobalservices.com/files/program\\_documents/scs\\_stn\\_ec10.3-2014\\_v4.0\\_031617.pdf](https://www.scsglobalservices.com/files/program_documents/scs_stn_ec10.3-2014_v4.0_031617.pdf)

Floors should be checked for damage on a regular basis. Potential slip and trip hazards to look for include holes, cracks, and loose carpets and mats. Any floor surface should always be suitable for the work carried out. In production facilities this might e.g. entail resistance to oil and chemicals used, which may spill onto the floor. Additional coating or chemically treating existing floors can improve their slip-resistant properties.

To help decrease the number of slips, trips, and falls, OSHA published a Walking-Working Surfaces and Personal Protective Equipment rule in 2016, developed to prevent these accidents, as well as other hazards<sup>53</sup>. The rule requires that in locations where hazardous conditions may affect the structural integrity of the walking-working surface, a qualified person must perform or supervise the maintenance or repair of that surface. OSHA defines a “qualified person” as “a person who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience has successfully demonstrated the ability to solve or resolve problems relating to the subject matter, the work, or the project.”

The majority of employees in general industry workplaces walk or work on level surfaces, such as floors, where slips, trips, and falls are common occurrences. These occurrences, however, are not likely to result in major injuries or fatalities. On the other hand, there are many employees who work on elevated levels and floors, where slips, trips, or falls are likely to result in serious injury or death<sup>54</sup>. There are many causal factors for slips, trips, and falls as well, such as wet areas, grease, and loose or uneven flooring or carpeting,

Although not mandatory OSHA's General Requirements for Walking and Working Surfaces sets forward the recommendation for a static coefficient of friction (COF) of 0.5 as a reasonable guide to provide proper slip resistance<sup>55</sup>. This coefficient of friction is defined as the force necessary to hold two materials (the foot and the floor) together and the maximum force necessary to resist sliding. Certain activities, such as carrying items, pushing or pulling objects, or walking up on down inclined surfaces may require a higher COF.

The slipperiness of flooring can vary depending on the conditions of the surface and the type of footwear worn by employees. Slip-resistant flooring that is serrated, punched, or textured to add to its roughness may offer some anti-slip protection, and OSHA recommends that it be used in wet, oily, or dirty work areas. Slip-resistant footwear can also help reduce slip and fall hazards in the workplace. The material, texture, cleanliness, and amount of wear of the floor surface contributes to its slipperiness. A well-worn floor is often more polished and hence more slippery than it was when it was new. The porosity of the floor will also affect its slipperiness. For example, a concrete floor will absorb water, while one coated with an epoxy will allow water to collect on the surface of the floor, increasing slipperiness.

## FROM THE GROUND UP

**Workers who remove and install flooring material such as carpet, granite, vinyl, wood, or laminate are especially exposed to hazards that can lead to serious injuries or death<sup>56</sup>. In addition to the abovementioned risks including falling and slipping, workers who do this type of work are exposed to a variety of hazards such as asbestos, chemical burns and silica.**



<sup>53</sup> <https://www.newpig.com/expertadvice/new-osh-floors-safety-rule-aims-to-prevent-workplace-fall-incidents/>

<sup>54</sup> <https://www.osha.gov/laws-regs/federalregister/2010-06-24>

<sup>55</sup> [http://safety.lovetoknow.com/OSHA\\_Standards\\_for\\_Flooring\\_Roughness](http://safety.lovetoknow.com/OSHA_Standards_for_Flooring_Roughness)

<sup>56</sup> <http://www.lni.wa.gov/Safety/Topics/AToZ/FlooringInstallation/default.asp>

<http://www.citbni.org.uk/CITB/files/c0/c0a05e40-758f-463f-a7e0-c62c86e565d4.pdf>

Before floor installers start their job, they should make sure that the room is as empty as possible<sup>57</sup>. Any electrical or other fittings that may be accidentally touched or damaged should be masked or removed. The electricity at the mains should also be switched off before removing electrical fittings. If using materials that give off fumes or vapor, one should ensure that the area is well ventilated as this will ensure that fumes are not inhaled.

<http://www.citbni.org.uk/CITB/files/c0/c0a05e40-758f-463f-a7e0-c62c86e565d4.pdf>

Asthma is major concern for floor installers. Within this occupational group it is predominantly caused by breathing in chemicals called “sensitizers”<sup>58</sup>. These are substances that can trigger an irreversible allergic reaction. Things to watch for in yourself and the people you work with can include: coughing, wheezing, tightness of the chest, constantly runny nose, and watery, prickly eyes. Substances known to cause asthma are: wood dusts, epoxy resins in some glues and resins, isocyanates in some paints, formaldehyde in some MDF, some paints and wood preservatives.

<http://www.lni.wa.gov/TradesLicensing/LicensingReq/Asbestos/default.asp>

Asbestos has been widely used in many building products because of its tensile strength and chemical and thermal resistance<sup>59</sup>. However, asbestos is extremely hazardous to workers handling it and conse-

quently inhaling it, because it's a carcinogen that causes lung cancer and mesothelioma. Breathing in crystalline silica dust over time can lead to a disabling lung disease such as silicosis or lung cancer<sup>60</sup>. Quartz is the most common type of crystalline silica mineral. The relationship between e.g. hardwood dust and nasal cancer is well known. It is common sense that breathing in dust of any type is likely to be harmful and can cause diseases such as bronchitis and emphysema. Dampening surfaces can help to reduce dust, as can working with hand tools rather than power tools.

<http://www.lni.wa.gov/Safety/Topics/AtoZ/Silica/>

Installing or stripping and replacing floors is usually done with the help of floor stripping chemicals. These are highly toxic and pose serious threats to human health if not used safely<sup>61</sup>. When stripping a floor, small razor or putty knives are commonly used for intricate detailing works in corners and other crannies. A careless slip can easily lead to a cut, so wearing a pair of cut-resistant gloves under rubber gloves to protect the hands is essential. Installing floors also means spending a lot of time on your knees, so one should wear hard plastic kneepads for support and protection.

<https://www.hunker.com/12003153/the-dangers-of-floor-stripping>

Health problems in floor installing can occur through inhalation and ingestion of certain chemicals as well. Some chemicals can expose workers to skin conditions such as dermatitis<sup>62</sup>. Work-induced skin irritation of the hands, arms, face, and lower extremities are the most common affected areas. The symptoms of dermatitis are: reddish skin; sores, itching, scales and/or blisters; cracked and bleeding skin when worsened. If left untreated the condition can lead to work disability, but it is preventable, and if spotted early it can be cured. Occupational dermatitis is caused when the skin comes into contact with certain substances at work. Some cause dermatitis by irritating the skin, others cause an allergic reaction. The length of time it takes to develop depends on the substance, its strength and potency, and how long or how often it touches the skin. Once someone has developed an allergic reaction, even the tiniest amount might bring on the dermatitis.

<http://www.citbni.org.uk/CITB/files/c0/c0a05e40-758f-463f-a7e0-c62c86e565d4.pdf>





The most common substances that cause floor installers to contract dermatitis include:

- Cement products;
- Latex rubber;
- Nickel and chromium;
- Epoxy and other resins;
- Oils, soaps and detergents;
- Some paints and wood preservatives.

A chemical burn is damage to the skin, airway passage linings or other bodily tissue that occurs after accidental or continual exposure to hazardous chemicals<sup>63</sup>.

They usually occur on exposed areas of the body, such as the face, eyes, hands, arms and legs. Many floor stripping products will cause painful chemical burns, which take only seconds to develop. Some stripping chemicals, like e.g. butoxyethanol, are absorbed through the skin and are so strong they can damage internal organs like the liver and kidneys. Furthermore many materials commonly used to paint or coat surfaces have also been found to irritate or burn the skin and eyes. Hence floor installers should always wear safety glasses and protective suits avoiding exposed skin.

The fumes released by floor stripping chemicals are toxic, inducing a variety of health issues, ranging from dizziness to nausea, headaches, chest pains and coughing. Exposure to products containing ammonia

in particular may cause severe damage to the respiratory tract in addition to heart palpitations and difficulty breathing. This makes the use of protective masks an absolute imperative.

**Alongside wearing adequate protective gear floor installers should limit exposure to the following toxins as much as possible:**

- Highly acidic industrial cleaners and solvents;
- Lime, which is still used in large quantities as a building material in cement, plaster, concrete, and mortar;
- Paint thinners or removers, like turpentine or acetone;
- Epoxy resins, which are often used in concrete, adhesives, surface coatings, laminates, paints and primers, and flooring and electrical insulation.

Besides preventive and protective measures, limiting or eliminating exposure to such toxins is your safest bet to avoid any health implications. This means choosing building materials and flooring types that do not contain these substances (or at least the smallest amount possible) and opting for flooring types that yield the shortest possible installation time required.

<sup>63</sup> <https://www.warren-kallianos.com/blog/skin-burning-chemicals-and-the-construction-workers-who-handle-them/>



**Don't let poor IAQ ruin your quality of life. Choose quality flooring.**

## CONCLUSION

We spend ever-more time indoors. At home, at the office, in school, in the gym, in public transportation systems ..., we are constantly exposed to much higher concentrations of pollutants and biological contaminants than would be the case outdoors, where these harmful substances evaporate and disperse much faster.

Our modern, indoor lifestyle has created worsening health issues, ranging from short-term illnesses to long-term medical conditions, and even fatalities. These negative effects are encountered across the board, from the general population to particular, vulnerable groups such as children, pregnant woman and elderly people. They not only affect families at home, but also create major health issues and considerable prejudices and costs in the form of health care, work-related accidents and illnesses, and school absenteeism.

In addition to a wide array of gases, microbes, particles, chemicals, and bacteria, the main culprits of poor IAQ are VOCs, namely organic chemicals that evaporate at ordinary room temperature, thus easily dispersing throughout buildings, and accumulating to much higher concentrations than outdoors.

Besides temporary and reactive measures such as proper ventilation, regular and thorough cleaning, and keeping a low and constant ambient temperature, the main structural, long-term solution consists of reducing and/or eliminating the main sources of VOCs, namely floors and other building materials.

**As far as flooring types are concerned, resilient floors offer the best safeguard against scratches and scuffs, caused by every-day wear and tear. These blemishes and crevices would otherwise cause accumulation of dirt, dust, and biological materials such as VOCs, which would in turn disperse throughout the house or building.**

**Make sure to always opt for low- or no-VOC options when selecting materials such as flooring, wall and ceiling materials, adhesives, paints, coatings, and sealants. Trusting independently developed, tested, controlled, and issued standards and accreditations such as FloorScore®, is your best bet at installing the safest and healthiest options.**

**Don't let poor IAQ ruin your quality of life. Choose quality flooring.**