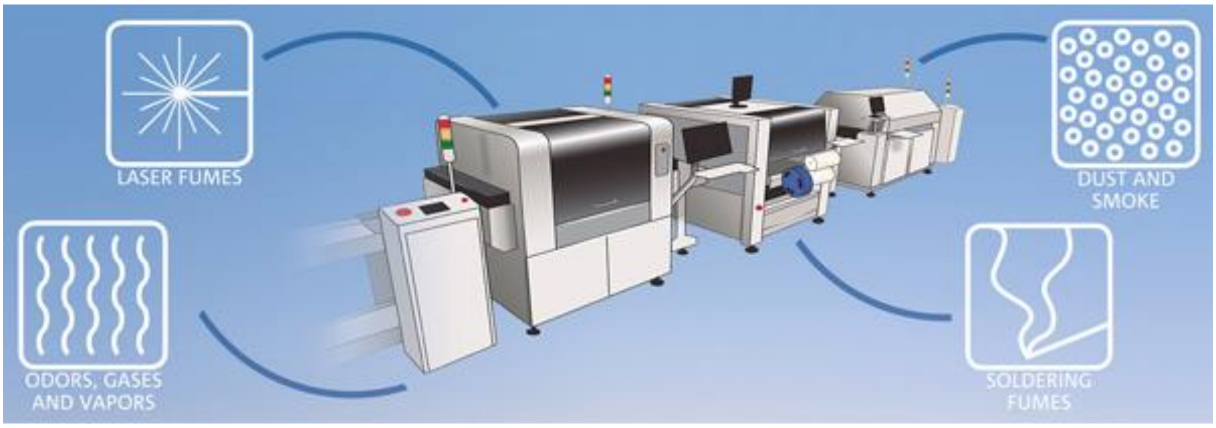
Air purification and occupational health & safety in electronics production

The overall process of manufacturing electronics assemblies is characterized by a number of very different procedures. Along the production chain, technologies for cutting, assembling, soldering, bonding, gluing, marking, potting, etc. are used, all of them have one thing in common: They produce airborne pollutants, some of which can have a significant impact on employees, manufacturing equipment and products - and for this reason need to be removed effectively and efficiently.



Why extraction and filtration?

Airborne pollutants are a collection of particles of different size and composition, each with different chemical and physical properties. The example of soldering fumes will be used to demonstrate their influence on the environment.

Solder fumes consist mainly of decomposition products of fluxes, soldering materials and residues of cleaning agents, which can combine to build sticky aerosols. They not only have a negative impact on the health of employees but can also build up firmly adhering layers of dirt and thus contaminate production equipment, which has a lasting negative impact on manufacturing quality. If, for example, manufactured electronics assemblies are contaminated with sticky dust, this may lead to corrosion of conductive paths, which could result in partial or even complete failure of functionality.

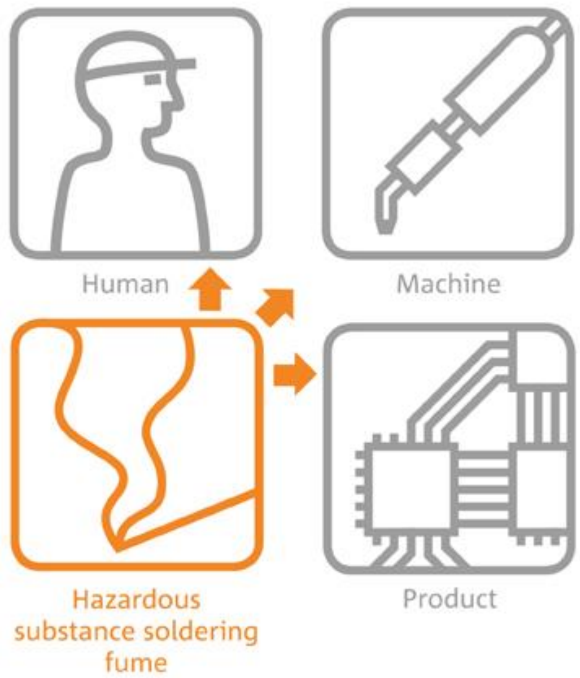


Figure 1: The threefold damaging effect of solder fumes on man, machine, and product

Airborne pollutants are classified according to particle size. This classification focuses primarily on the influence of emissions on human organism. Thus, airborne pollutants are not only differentiated, whether they are brain-, nerve- or respiratory tract -damaging.

A distinction is made, whether they are inhalable (I-fraction) or alveolar (A-fraction). Therefore, statutory limit values are defined in DIN EN 481. As an example: According to German Technical Rules for Hazardous Substances 900 (Technische Regel für Gefahrstoffe (TRGS)) the limit values are 10 mg/m³ for the I-fraction and 1.25 mg/m³ for the A-fraction. The legal regulations of Technical Instructions on Air Quality Control (Technische Anleitung zur Reinhaltung der Luft, (TA Luft)) limits the total dust mass-concentration including fine dust to a max. of 20 mg/m³.

However, this only applies to dusts that are harmless to health and does not include the so-called CMR substances (carcinogenic, mutagenic, toxic to reproduction). For sure, there are similar regulations in many countries.

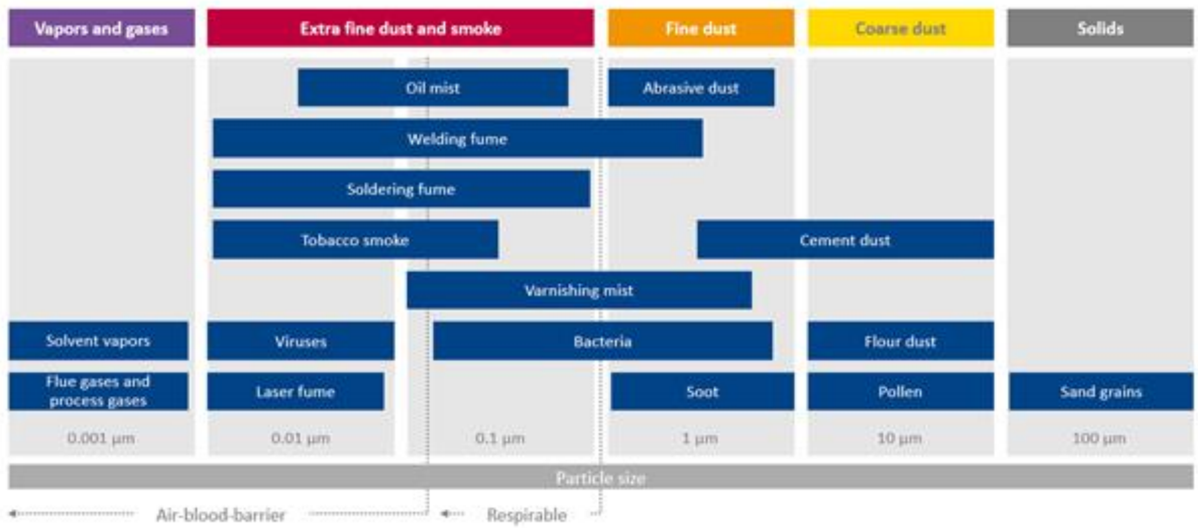


Figure 2: Comparison of article type and size

Common air pollutants and their optimal filtration

Airborne pollutants can be found at a wide variety of places in electronics manufacturing.

Soldering fume

Soft soldering methods are used to a large extent in the manufacturing process, including wave, reflow, vapor phase, laser, or manual soldering. This produces a variety of hazardous substances, e.g., organic tin compounds, hydrogen chloride, formaldehyde, acetaldehyde, acrylaldehyde or butyraldehyde. The following solder fume concentrations were recorded during hand soldering:

- Concentration with leaded solder: approx. 1.0 mg/m^3
- Concentration with lead-free solder: approx. 1.3mg/m^3

The percentage and quantities of these compounds depend on the composition of the solder and the soldering temperature.

Due to the mix of pollutants in the solder fume, combined filters are used for optimal filtration. These are made up of a combination of resublimation filters, particle filters in several stages and adsorption filters.

In larger wave soldering systems, separate filtration of flux and solder wave is executed. When flux containing solvents are used, fans equipped for potentially explosive atmosphere are used to prevent explosion or fire.

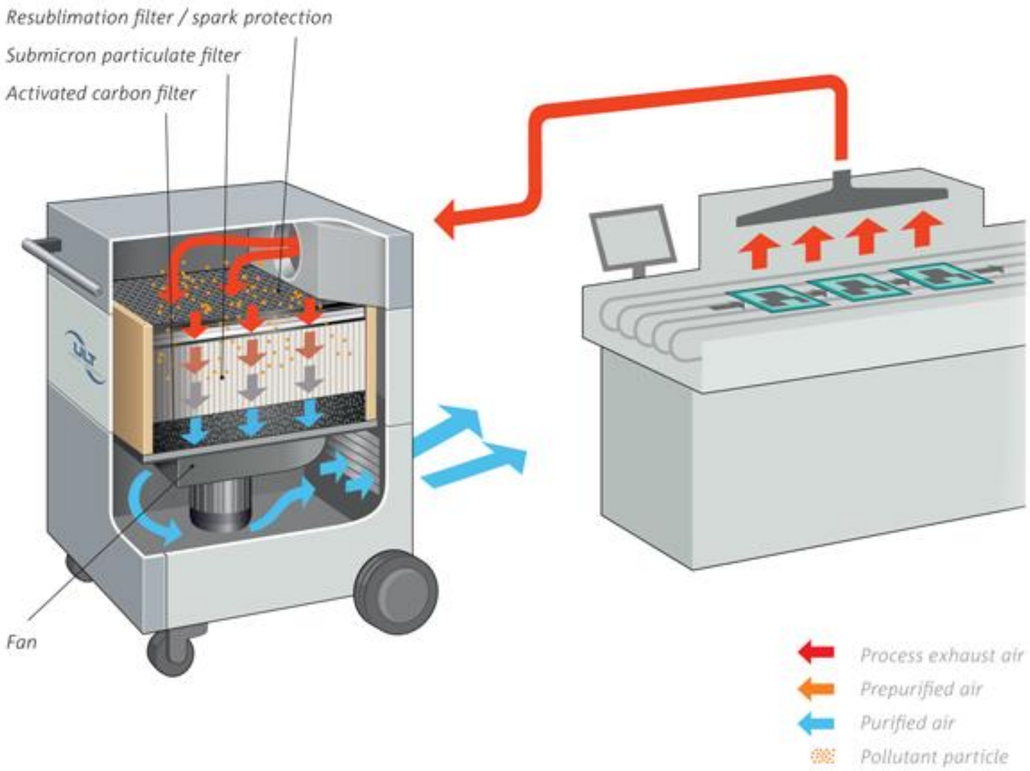


Figure 3: Extraction system with storage and sorption filter modules for capturing soldering fume and vapors

Gases and vapors

Gases and vapors are released during e.g., printing, potting, painting, gluing or cleaning. Typical pollutants are isopropanol, toluene, acids, butanol, or resins.

Relevant substance data is determined based on the respective material safety data sheets (MSDS). As a result, the type of filtration is determined. In this case sorption technologies, i.e., adsorption by means of activated carbon or chemisorption by means of chemically modified adsorbents, are used. The MSDS also provides information on explosion limits. If the lower explosion limit cannot be safely undercut, explosion-proof fans must again be used in the extraction system.

Dust

Dust is generated in electronics manufacturing, for example, during cutting, milling, grinding, polishing, or decanting. Typical pollutants are coarse dust, fine dust, and odors. Dry dusts are usually separated through cartridge filter systems. The filter cartridges can be cleaned and hence utilized for a relatively long period of time. All dusts must be checked for flammability before they are extracted and filtered, as in such case explosion-proof systems must be used in order to comply with occupational health & safety and explosion protection.

Laser fume

Laser fume is mainly generated during marking, separating, decoating or structuring. Typical pollutants are often nanoscaled particles, but also aerosols and gases.

During laser processing, a material transformation takes place through pyrolysis, oxidation, reduction, or polymerization. This requires special filter combinations. Furthermore, the composition of the laser smoke is determined by the type of laser source and, therefore, the energy input.
Due to the combination of pollutants in laser fume, combined filters are often utilized for ideal filtration. As in the case of soldering fume extraction, these are made up of a mix of resublimation filters, particle filters in several stages and adsorption filters.

Due to the diversity of laser fume, filter geometries and their gradations are adapted to the application. Cleanable filter systems are also utilized. The addition of filter aids increases the separation quality and thus the filtration performance.

Capturing of air pollutants

Capturing the airborne pollutants is a significant aspect of air purification. This is usually done via capturing elements, extraction arms and connected accessories. Size and type are determined by the pollutants themselves, their thermal properties and other air movement influences.
The level of capture and separation efficiency are essential for the efficiency or filtration performance of the respective extraction system.
Proximity to the source of emission is crucial - the closer, the better. Not only in terms of capturing the majority of all particles before they can spread, but also to minimize economic expenses. There is a rule of thumb that twice the distance between the emission source and the capturing element requires at least four times the suction power of the extraction and filtration system.

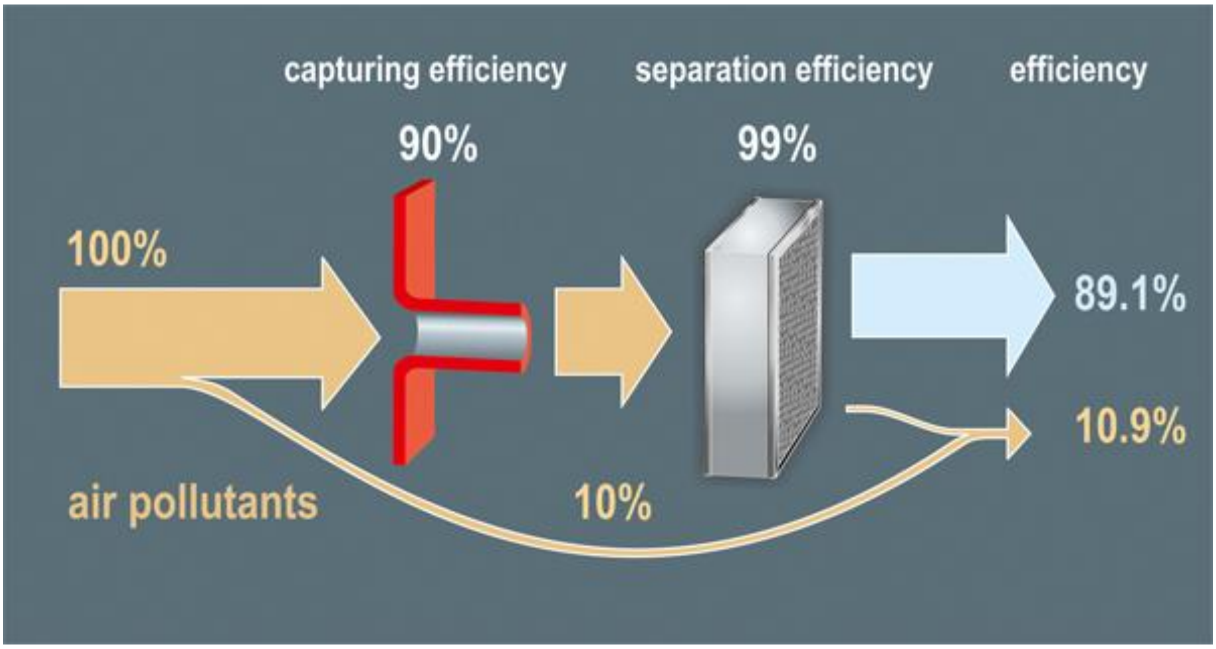


Figure 4: A high degree of capture and separation increases the air purification performance of a filter system

The use of the optimum capturing element, extraction arm or extraction hose is determined by the application. In production lines, extraction and filtration systems are often integrated directly into processing equipment, e.g., laser markers or soldering systems. Accordingly, the pollutant capturing takes place in the encapsulated system and serves primarily to protect the plant itself as well as the manufactured product. Different variants are available for manual workplaces.

Thus, a filtration unit can be used as a central extraction box. The respective workstations are equipped with collection elements that are connected to the system via pipes or hoses. The exhaust air flow is activated or deactivated via damper flaps.

Depending on the number of pollutants produced, each manual workstation can likewise be equipped with an extraction system. In this case, mobile systems are primarily used, which are particularly suitable for changing workplaces.

Individual design

In electronics manufacturing, while many procedures are standardized, the variety of materials used and to be processed often requires an individual analysis of the pollutant situation. The use of different organic, inorganic, or toxic substances up to the use of precious metals, the recycling of which must be taken into account when selecting filters, are just a few examples of the “normal abnormal”. Standard solutions are of no help here. The respective production situation must be assessed individually, and a corresponding special solution is to be engineered.

In addition to the extraction and separation performance of a filter system, other parameters such as noise level, robustness or floor space requirements also come into play. In addition to enjoying purified clean air, employees do not want to be disturbed or hindered in their daily tasks.