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7.2 Laser printers and copiers

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Laser printers and copiers have become an indispensable part of modern office life, used by millions of people every day. However, reports of potential health hazards due to laser printers purportedly causing exposure to toner dust have provoked public concern on more than one occasion. It was this concern that, more than a decade ago, prompted the Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA; Institute for Occupational Safety and Health of the German Social Accident Insurance, formerly known as BGIA) to conduct numerous projects on this topic in cooperation with the Verwaltungs-Berufsgenossenschaft (VBG; German Social Accident Insurance Institution for the administrative sector). The aim of this work was to identify the emissions released by laser printers and copiers and to assess whether they were potentially harmful to health [1 to 3]. In addition to the IFA's activities in this field, the Landesgewerbeanstalt Bayern (LGA Bayern; Bavarian state trade agency) emission-tested various devices and toners between 2000 and 2007 [4]. The findings of this research remain valid today since printer technology has not undergone any significant change since then. They show that laser printers and copiers do not emit significant amounts of dust or gas (see the sections on the individual substance categories).

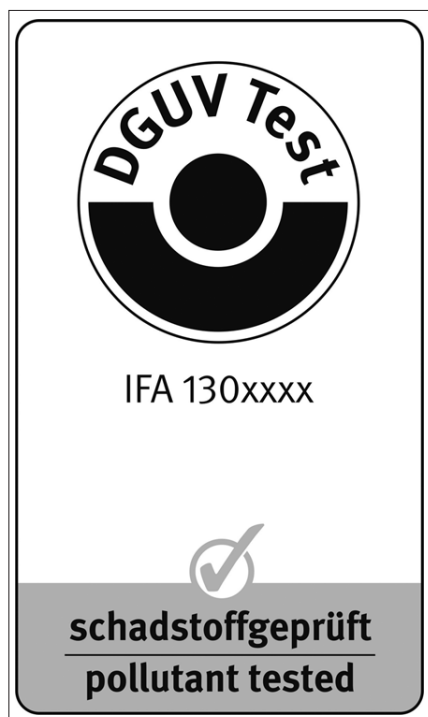
In the interests of environmental and user protection, the “Environmental Label Jury” has developed award criteria, referred to as RAL-UZ 122 [5] and RAL-UZ 171 [6], for office equipment that has a print function (printers, copiers and multifunctional devices (MFDs)) (Figure 7). As well as general requirements, e.g. recyclability and power consumption, and toner substance requirements, a major part of the awarding process involves emission testing. Chamber tests are carried out to determine the quantities of dust, ultrafine particles (UFPs), ozone, TVOCs, benzene and styrene emitted. The emissions are assessed on the basis of the current guideline values for environmental or indoor emissions, which are far lower than the applicable occupational exposure limits (OELs).

Generally speaking, the equipment is only tested in combination with the toner and paper sold for the specific device in question. In practice, however, the toner used often comes from a different manufacturer or in a recycled toner cartridge and has not been tested in conjunction with the device. The former Fachausschuss Verwaltung (Expert Committee for the Administrative Sector) has therefore created an additional DGUV Test certification mark for toner powder, which indicates that the product has been pollutant-tested (Figure 8) [7]. The intention is that this will assist buyers of toner cartridges when judging quality and comparing products. Toners bearing this mark meet strict requirements concerning the metals, volatile organic compounds and other substances they contain as well as particle size.

Figure 7:
“Blue Angel” for office equipment with a printing function
(printers, copiers and MFDs)



Figure 8:
Special DGUV Test “pollutant tested” mark



Paper is a source of emissions too. Due to the design parameters for laser printers, the paper is briefly heated to roughly 150 to 200 °C, which can cause it to give off certain substances. The award criteria for the Blue Angel RAL-UZ 14 eco-label [8] for recycled paper (Figure 9), which include numerous environmental aspects, also consider potential emissions of volatile organic compounds if the paper is of a type intended to be used with electrophotographic printers or copiers (known as copying paper).

In situations where laser printers are used a great deal or several devices are operated simultaneously, it is always recommendable to place them outside the office.

Figure 9:
“Blue Angel” for recycled paper



7.2.1 Dust

The research conducted by the BGIA (now IFA) and LGA Bayern did not reveal any significant toner dust emissions. The RAL-UZ 122 and RAL-UZ 171 award criteria give an emission rate of 4.0 mg/h of dust (usually paper dust) as the maximum permissible value during the printing phase.

7.2.2 Metals

Most black toners have an iron content of 25 to 33%, in the form of iron oxide. The research carried out at the BGIA detected parts-per-thousand levels of titanium, strontium, copper and zinc compounds.

The copper and titanium content of colour toners is usually low. The IFA (formerly BGIA) also found chromium, iron, zinc, tin and strontium in various colour toners. The cobalt and nickel content (substances that are particularly problematic because of their sensitising effect) of the toners was either zero or trace.

For a toner to be awarded the “pollutant tested” mark, it must comply with the maximum content levels shown in Table 10 for the various metals contained in toner powder, which are specified in the “Grundsätze für die Prüfung und Zertifizierung von Tonerpulver schwarz und farbig für Laserdrucker und Kopiergeräte” (Code of rules for testing and certifying black and colour toner powders for laser printers and copiers) [7].

The award criteria for the Blue Angel eco-labels RAL-UZ 122 and RAL-UZ 171 go even further. They stipulate that toners must not contain any substances whose constituent parts include mercury, cadmium, lead, nickel or chromium(VI) compounds. The exception is nickel complexes with a high molecular weight, which may be used as pigments. Contamination with heavy metals, such as cobalt or nickel oxides, caused by the manufacturing process must be kept as low as technically possible and economically viable [5; 6].

Table 10:
Limit values for metals in toners in accordance with the requirements for the DGUV-Test “pollutant tested” mark

Metal	Limit value in mg/kg
Cadmium	5.0
Cobalt	25
Nickel	70
Lead	25
Mercury	2.0
Chromate (in the form of chromium)	1.0
Organotin compounds (in the form of tin)	5.0

7.2.3 Ozone

Modern laser printers do not usually emit ozone. In fact, today’s black and white laser printers mostly use ozone-free technology, which means they do not need an ozone filter. Black and white and colour devices that do produce ozone only emit negligible quantities, at a level that can be regarded as not harmful to humans, provided the ozone filter is intact and working properly. It is therefore imperative that maintenance be carried out regularly, including filter replacement where necessary. If this is not done, the ozone concentrations can increase to a much higher level. This is particularly an issue with old devices [1; 4]. In accordance with the award criteria for the Blue Angel RAL-UZ 122 and RAL-UZ 171 eco-labels, black and white devices must not exceed an ozone emission rate of 1.5 mg/h during printing and colour devices must not exceed 3 mg/h. When judging the ozone concentrations produced by laser printers during printing, it is important to bear in mind that ozone breaks down into oxygen on walls and other surfaces. The half-life for this process is approximately 30 minutes. In other words, once half an hour has passed, the amount of ozone is only half of what it was originally. If ozone is continuously emitted (from equipment or the outside air), the ozone formation and breakdown processes balance each other out.

7.2.4 Volatile organic compounds (VOCs)

All laser printers and copiers emit volatile organic compounds (VOC) during printing and copying. This is due to technical factors and practically impossible to avoid with today’s technology. Consequently, when assessing laser printers it is not important to determine whether they emit VOC but rather to establish the nature and quantity of the compounds released. The award criteria for the Blue Angel eco-labels RAL-UZ 122 and RAL-UZ 171 specify the following maximum values for total volatile organic compound (TVOC) emissions:

- 10/18 mg/h
(black and white/colour device) during printing

The award criteria for the special DGUV-Test “pollutant tested” mark specify a maximum TVOC content of 1,000 mg/kg for toners.

The criticism surrounding these devices mainly concerns benzene, which can be emitted during printing and is classified as a carcinogen [9]. Though many black and white and colour laser printers do not give off any benzene at all, some have been found to do so. The LGA Bayern investigated benzene emissions from laser printers extensively, focusing on:

- Benzene content in toners
Based on 585 toners examined, the mean value was 3 mg/kg and the median was < 0.1 mg/kg.
- Benzene emission rates from laser printers and copiers
Based on 266 devices examined, the mean value was 0.09 mg/h and the median was 0.04 mg/h.

When the LGA Bayern began conducting these investigations, in 2000, benzene was detected frequently. In the years thereafter (up until 2007), it only found the substance on rare occasions. Both the LGA Bayern investigations and the IFA’s activities in this field have proved that most devices do not emit any benzene or only emit insignificant quantities of the substance, usually equivalent to the general level of benzene pollution in the environment.

The award criteria for the RAL-UZ 122 and RAL-UZ 171 Blue Angel eco-labels set a maximum benzene emission rate of 0.05 mg/h during printing. The award criteria for the DGUV-Test “pollutant tested” mark for toners specify a maximum benzene content of 1 mg/kg.

The Senatskommission zur Prüfung gesundheitsschädlicher Arbeitsstoffe (Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area) of the Deutsche Forschungsgemeinschaft (DFG; German Research Foundation) has classified styrene, which is also emitted from such products, as “carcinogen category 5”. This means that its *“intensity (...) is considered so low that no significant contribution to the risk of cancer to humans is anticipated provided the MAK value is adhered to”* [10]. The measurements carried out by the BGIA found the concentrations to be lower than two hundredths of the OEL. A few devices, however, did exceed the indoor air guide value I (30 µg/m³) specified by the Umweltbundesamt (UBA; Germany’s Federal Environment Agency) [11].

The LGA Bayern also examined styrene emissions. The mean value for the styrene emission rate for the 266 devices in the period 2000 to 2007 was 0.9 mg/h and the median was 0.27 mg/h.

The award criteria for the Blue Angel eco-label specify a maximum styrene emission rate of 1.0/1.8 mg/h (black and white/colour device) during printing. To be awarded the DGUV-Test “pollutant tested” mark for toners, toners must not exceed a styrene content of 40 mg/kg.

The devices also emit varying quantities of other volatile organic compounds, such as toluene, xylenes, ethylbenzene and trimethylbenzenes. However, all of the concentrations measured were several orders of magnitude below the current occupational exposure limits.

7.2.5 Overall assessment

The following conclusions can be drawn from the investigations described above:

- Modern laser printers and copiers do not emit significant amounts of toner dust during printing. Consequently, there is no reason to assume a heightened health risk due to toner dust being absorbed through the respiratory system. If there is a possibility that, for example, toner dust might be emitted into the air when refilling cartridges, appropriate exhaust systems must be installed.
- If cartridges are replaced as prescribed, the toner does not usually come into contact with skin. If contact with the toner cannot be ruled out for certain devices, protective gloves should be worn when replacing the cartridge. Should contact with the skin occur despite this precaution, the toner must be removed from the skin using cold water and soap. Employees who potentially have frequent contact with toner (during servicing or recycling tasks) should always wear protective gloves to rule out any chance of direct contact with toner.
- Nowadays, laser printers do not pose a problem in terms of ozone formation since many devices already have completely ozone-free technology. Where devices do produce ozone, it is crucial that the ozone filter is maintained as prescribed. Spent ozone filters can cause the ozone values to increase. People who are very sensitive to ozone should certainly look for devices with ozone-free technology. If a laser printer is to be replaced anyway, preference should be given to devices with ozone-free technology.
- All laser printers emit VOC to varying degrees. The concentrations measured are several orders of magnitude lower than the occupational exposure limits in force. With the exception of the indoor guideline value I for styrene, which is occasionally exceeded, they also comply with the considerably more stringent environmental and indoor guideline values. The emitted quantities of the carcinogenic substance benzene corresponded to the general level of benzene pollution in the environment. Nonetheless, as it is not possible to specify a threshold value for the carcinogenic effect of benzene, it is up to device and toner manufacturers to enhance today's technology to ensure that future products do not emit any benzene.

7.2.6 References

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