Scientific background
&
Frequently Asked Questions
on the technology of OZONOS®

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TABLE OF CONTENTS

INTRODUCTION

In our time, ozone is very often associated with negative issues and reports. For example, ozone is often viewed as an environmental polluter, is classified as poisonous (toxic) or is equated with smog. The infamous ozone hole in the stratosphere, which transmits harmful ultraviolet radiation onto the earth's surface, is another guarantee for negative headlines.

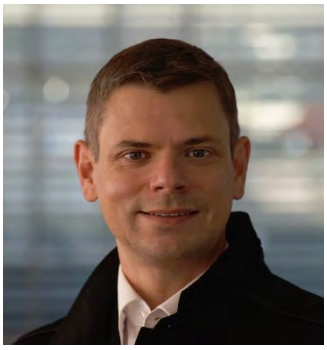
All of this is a very one-sided perspective. Ozone is one of the strongest natural cleaning substances and is already used very successfully in industry and commerce in a variety of application scenarios. For example, in water treatment, wastewater treatment, odour control, exhaust gas cleaning or in the cleaning of industrial systems. Ozone devices can be found in dairies, sewage treatment plants, the textile industry, hospitals, breweries, the food industry, swimming pools, waste management companies, bio-gas processing or on oil platforms.

The OZONOS Aircleaner is the first product that makes this potential usable "in a gentle manner" for home use – and being not only stylish but also safe, quiet and flexible! This is exactly where the patented innovative power of the OZONOS Aircleaner is to be found.

The following questions and answers provide rich and scientifically sound background information and arguments as to why the OZONOS Aircleaner works and is safe.

The formulations chosen and the composition of the texts are subject to a certain degree of movement between their general intelligibility and their scientific basis.

The content and justifications in this document have been assembled by the author and are based on a scientific literature search, on the experience and information provided by the manufacturer and on measurements in internal studies which have been carried out for OZONOS by the author.



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BACKGROUND KNOWLEDGE ABOUT OZONE

1. When was ozone discovered?

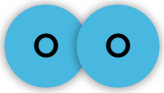
The **discovery** of ozone in **1839** is attributed to the German scientist **Christian Friedrich** Schönbein[1]. At that time, ozone was considered to be a gas with a strong intrinsic odour, which played an important role in oxidation reactions. The name ozone comes from the Greek, "ozein" (= to smell). The **chemical composition** was characterised in **1856** and the chemical formula in 1861[1]. This also showed that ozone and the oxygen in the air that we breathe are closely related to each other. Both consist of oxygen atoms O.

2. What is ozone?

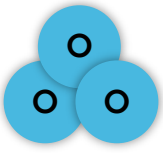
Ozone is a form of oxygen O (containing oxygen atom). An oxygen molecule O_2 (molecular oxygen) consists of two oxygen atoms O with a very strong, stable bond between them. **O_2 is the main component of the air which we breath** (approximately 21%) and is colourless, odourless and tasteless. If O_2 were to disappear from our environment, it would be painfully noticeable – along with water, O_2 is the most important basis for life.[1]

An **ozone molecule O_3 consists of three oxygen atoms, O**. The additional bond of the third oxygen atom is very weak compared to the bond between the other two. This **weak bond** means that the ozone molecule is inherently unstable.[1,2,3] Nature always attempts to move from an **unstable** to a stable state. **For this reason**, **the ozone molecules react** with the first possible molecule that can form a bond (= oxidation).[1,2] It is this physical property of ozone that does the work with the OZONOS: the reaction with odours and other impurities in the air.

Oxygen O as an atom



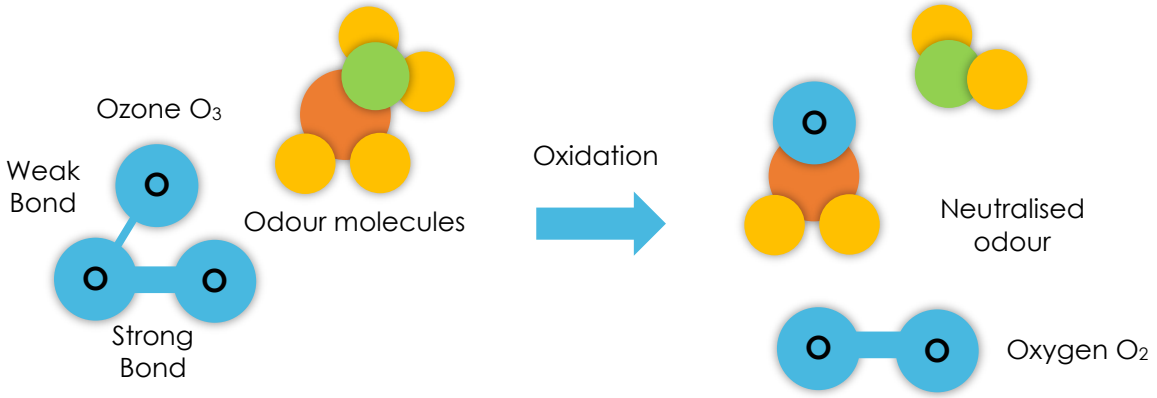
Molecular oxygen O_2



Ozone O_3

3. How does ozone work?

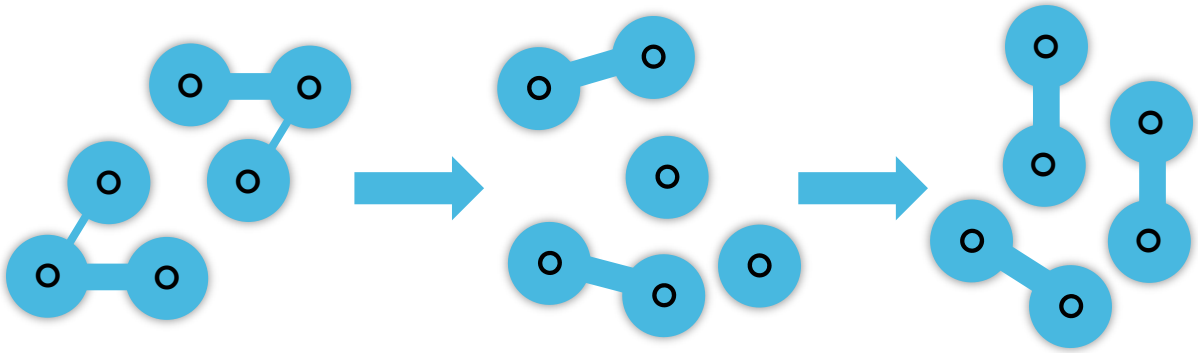
In contrast to O_2, **ozone** O_3 **is unstable**, as one of the oxygen atoms has only a **weak bond** to the other two atoms. If it finds a **suitable partner**, for example an odour molecule, **ozone will immediately react** with it. The weakly bonded oxygen atom O is released to the molecule. **This reaction is called oxidation**. As a rule, the partner molecule **decomposes** in this reaction or, at least, changes the properties[4]. The **rest** of the ozone, that is the molecular **oxygen O_2**, remains as normal atmospheric oxygen.[5]



Particularly popular partners in our indoor air are **albumens** (= proteins)[6,7,8], **fats** (short-chain fatty acids, volatile fatty acids, VFA)[9,10] **or other organic compounds** (volatile organic compounds, VOC)[11,12,10,13,14]. Therefore, ozone is particularly suitable for air purification and has been used for this for a long time.

The **oxidative effect is also disinfectant**[15,16,17]: germs, bacteria and viruses can be deactivated by ozone[18,19,20,21]. This happens, for example, when the ozone directly damages the cell membrane[15,16,22] or penetrates into the cell and destroys the multiplication mechanism as a free radical[16,23]. However, studies also show that the **ozone concentration must be very high for professional** disinfection, especially for surface disinfection[20]. The necessary concentrations cannot be achieved with OZONOS products. The **OZONOS** is therefore **not a disinfection** method (= inactivation of the germs, so that contagion/infection is no longer possible) in the narrower sense. The **disinfecting effect** of the OZONOS is supported **by** the **UV-C light in the** device. UV-C light is **a common method for disinfection**, because the UV-C rays destroy the genome of germs, bacteria, viruses, mould and fungi.[24,25]

In fact, ozone is so unstable that it decomposes **on its own** after a while **even in the absence of suitable reactants**[26]. In this case, the released O atom looks for another isolated O atom and again forms atmospheric oxygen O_2.



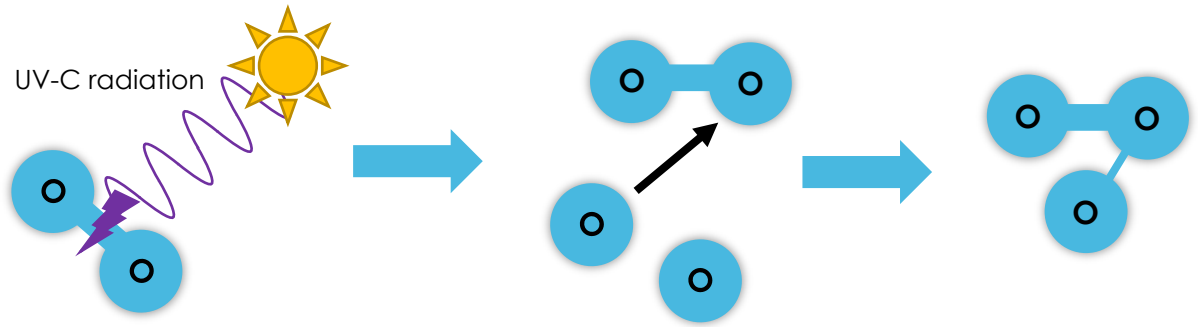
The great advantage of **ozone** is that it **does not react with the natural components of clean air**. The following are found in our breathing air or atmosphere: nitrogen N_2, oxygen O_2, argon Ar, carbon dioxide CO_2, neon Ne, helium He, methane CH_4, krypton Kr[27]. All of these substances remain completely unaffected by the presence of ozone. Humidity, that is, water vapour, also has no influence. Humidity only accelerates the decomposition of ozone[28,26]. In short, **clean air remains clean air** and ozone is a natural component in low concentrations[29] or simply decomposes back to oxygen after some time without residue[26]. You cannot avoid ozone completely.

4. How and where does ozone form?

Ozone is generated In natural and artificial processes from the available oxygen O_2 in our surrounding air or atmosphere[15]:

Possibility 1: The high energy of UV-C **rays** decomposes the **oxygen in the** air. The individual O atoms can now combine with another $O_2$to form O_3.[1,30]

Where does that happen naturally?	**And where artificially?**
Ozone layer[1,30]	OZONOS, sunlamp (UV lamp)[31]



Possibility 2: The **oxygen in the air** is **broken up by high electrical** voltage (corona discharges)[32]. The individual O atoms can now combine with another O_2molecule to form O_3.

Where does that happen naturally?	And where artificially?
Lightning during a thunderstorm[33,34]	Ozone generator, copier[35], printer[36]

Possibility 3: Due to the high energy of incoming **UV radiation** an O atom is split off from the toxic **air pollutant, nitrogen dioxide NO_2**[37] . The single O atom can now combine with another O_2 molecule to form O_3. What remains is toxic nitro-gen monoxide[38] NO.[39]

Where does that happen naturally?	And where artificially?
Lightning is a natural NO_2 source[33,34]	During summer smog from NO_2 exhaust gas[39]

5. Is ozone natural?

Yes, ozone is a **natural part of the atmosphere**: even in a perfectly clean environment without human beings, ozone would be present. On the one hand, in the **ozone layer**[1,30], on the other hand, ozone is generated by **discharges during thunderstorms**[33,34] or **in strong sun**[29] even in clean air and close to the ground.

Low concentrations of ozone are a completely natural component of our breathing air!

Even in **rooms** ozone is found in **low** concentrations[29]. It is believed that in the vicinity of waterfalls and forests, small amounts of ozone are generated from the negative ionised air that occurs there. Reliable scientific documentation is still missing. Research has already discovered this topic.[40,41,42]

6. In what concentrations does ozone occur in nature?

In the open air, **with** sunshine **and clean** air, **concentrations** of **up to 0.06 ppm are possible**. These values were measured, for example, in Death Valley in the USA – admittedly, an extreme example.[29] **In our latitudes,** a maximum of **0.03 ppm** can be expected in sunny conditions and clean air[160].

The **concentration** is lower **indoors**[29]. Firstly, the sun is missing as a generating factor and, secondly, the ozone reacts with impurities in the air. In the meantime, it is even assumed that the presence of human beings causes the ozone to decompose more quickly because the ozone reacts with grease on the skin[43,44]. Accordingly, values of a maximum of **0.005 ppm** indoors are more realistic as a basic concentration[45,29]. The ratio between outside and inside concentration is estimated at 30% and 70%[29]. If the summer smog is heavy, an open window can also cause the indoor ozone concentration to rise[29].

During **summer** we have **not only much higher concentrations** in cities **but also in the** mountains[160]. This is due to air pollution. The toxic nitrogen dioxide NO_2[37] is the main cause of the high ozone concentrations[39]. **In 2017** the highest measurements were 0.114 ppm in Vienna, Lobau[160] and 0.119 **ppm in the West Eifel**[162]. That is **just below the alarm value** of 0.12 ppm[166]. The lower information threshold was exceeded in Austria in 11 days and at 23 measuring points in 2017[160]. It[162] is similar in Germany[46] and Switzerland.

Indoors, **copiers and laser** printers should also be mentioned. These can produce up to **0.09 ppm** in the immediate vicinity during a mass printing[35]. There are also various welding processes that produce harmful amounts of ozone. For example, with **MIG** welding, up to **0.40 ppm** ozone can be reached in the surrounding air[164]. Respiratory protection is absolutely necessary here.

Further examples can be found in Question 52, Page 33.

7. How do you recognise natural ozone in nature?

Theoretically the odour (see Question 8, Page 9). The natural ozone concentration is usually so low that it is below the detection threshold, especially indoors. The **odour of ozone** is **usually or overlaid mixed with other odours** and there is a habituation effect[54]. During the summer smog and during thunderstorms, other air components with a strong odour, especially nitrogen oxides NO_x, are superimposed on the very characteristic odour of ozone.[47]

Outside the scientific literature, the odour of ozone (in low concentrations) is often described as the **"fresh, clean odour" after a thunderstorm** or nearby **a waterfall**. [48,49,50]

8. Can you detect ozone?

Yes, by the odour! One cannot sense ozone (in low concentrations), taste it or see it. It only occurs as a **gas** and has a very **characteristic odour**. The odour is described as **hay, clove, chlorine or**[37] nitrogen-like[47]. Since these odours are not generally known, one would simply describe the odour as a **fresh,**[3] **possibly me-**

tallic, odour. Since it occurs in the open air without air pollution in **low concentrations** up to 0.03 ppm[160] and/or is masked by other substances[47], we **are mostly unaware of the pure odour of ozone**.

A particularly sensitive **human nose** can detect ozone in fresh air as a fresh, possibly metallic odour over a **concentration of 0.0076 ppm,** see Question 63, Page 42. Everyone should be able to smell it **at 0.03 ppm at the most.** [51,52] The Bavarian State Office for the Environment specifies the odour threshold as 0.02 ppm to 0.025 ppm[53]. A habituation effect can be observed **with** the odour of ozone. This means that, after a few minutes, the odour is no longer perceived or weaker.[54] Nevertheless, in comparison, the air quality limit level for being harmless is 0.06 ppm[166]. This means,

ozone can be smelled
before it reaches an unhealthy concentration.

At **higher concentrations over 0.06 ppm** ozone slowly begins **to** smell **unpleasant**.[39] The odour can also be pungent. Ozone can be detected in summer in some cities or in the mountains as part of the summer smog, but is often not perceived consciously due to the many odour overlaps and the habituation effect. At **higher concentrations,** ozone slowly becomes **pungent-sharp to chlorine-like**. This is due to the oxidative properties of ozone[55] and the fact that ozone begins to irritate the mucous membranes.

The great advantage is that **nobody would stay in rooms with increased concentration over a longer period of time**. It would be completely natural to open the window or look for open space. This at least confirms the experience of the manufacturer and our own tests.

9. What does ozone have to do with summer smog?

Ozone is a major component of summer smog and often attracts negative headlines in the media. However, ozone is **not caused directly by human beings**. It is generated chemically as a **result of other air pollutants**.[39]

Above all, there is the toxic **nitrogen dioxide NO_2**[37], which **together with** the **UV radiation** from the sun generates the ozone[39] (see Question 4, Page 7). Volatile organic compounds (VOC) and carbon monoxide (CO) also support ozone formation.[39] The big problem here is that high and harmful concentrations above 0.06 ppm[165] are reached in summer smog. Even the information threshold of 0.09 ppm[165] is regularly exceeded.[160,161,162,163]

10. What does ozone have to do with the stratosphere and the ozone layer?

In recent decades, the **attention** of scientists, the media and **the public** has increasingly focused on the so-called **ozone hole**. The troposphere in which we human beings live extends from 10-15 km above the surface of the earth. The **stratosphere** above that goes up to about 50 km. The **ozone layer is to be found in that**. The **concentration of ozone** in the stratosphere **depends on the degree of solar radiation**. The **highest concentration is at 30 to 35 km altitude and is about 8 ppm**[56]. For comparison, the OZONOS AC-1 does not exceed 0.05 ppm.

In the stratosphere, **ozone** is continuously formed **by the high-energy UV-C radiation component of the sun** (see Question 4, Page 7). The oxygen O_2 absorbs the energy of UV-C radiation and splits up. Ozone O_3 is formed. **At the same time, ozone absorbs UV radiation and decomposes again** into O_2. This **ozone-oxygen** cycle is responsible for ensuring that relatively little of the harmful UV-C and UV-B radiation reaches ground level. As a result, the ozone layer protects us from the negative effects of harmful UV-C radiation, a typical cause of skin cancer.[57,30]

In the 1970s, the ozone concentration in the ozone layer decreased globally. The well-known **ozone hole** has emerged over the Antarctic since the 1980s. The **cause** of the formation of the ozone hole is attributed **to** the fluorine-chlorine-hydrocarbon compounds (CFCs), but other substances such as nitrous oxide also contribute to this. These substances cause ozone to decompose much faster than it is generated. Thus, the dangerous UV-C radiation can penetrate to the surface of the earth, which is so dangerous for us and nature.[57]

11. Is ozone toxic or dangerous?

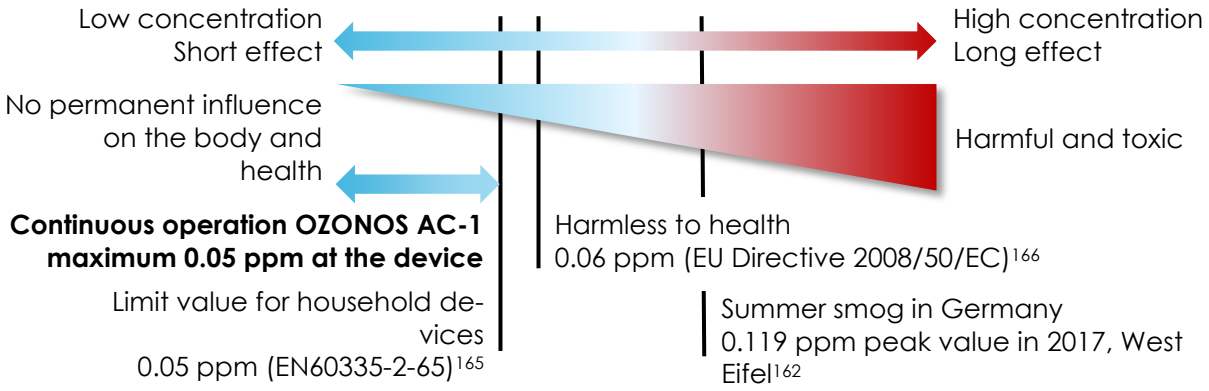
Yes and no! As **Paracelsus** said, **"The dose alone makes the poison"**[58]. High doses of sunlight and oxygen are also harmful[30] or toxic[59]. Just think of a sunburn here.

Whether ozone poses a health risk depends on personal sensitivity, concentration, duration of effect (= exposure) and physical exertion.[60,39]

The danger is basically similar to that of radioactivity. It simply depends on the dose (= amount of a substance over a specific time). For example, a short x-ray in hospital (low radiation) is not dangerous but a walk around the reactor block 4 of Chernobyl is.

The danger of ozone is the very strong oxidative effect.[61,60]

Ozone is dangerous for individual cells, for example, **bacteria, human, animal and plant cells**. Also **viruses, mould or fungi only weakly resist ozone**. Ozone can destroy the cell envelope or penetrate into the cell and damage it from the inside.[15,16] For details, see Question 40, Page 26.



Animals and human beings are much better protected **by the skin**. Fats, acids and dirt particles are enough to break down ozone[43,44] before it reaches and damages living skin cells. For details, see Question 41, Page 27.

Ozone is dangerous for human beings and animals in another way. The **respiratory tract, mucous membranes and eyes are the places that ozone can actually irritate**.[62,60,63] Therefore people with chronic respiratory disease (for example, asthma or COPD)[64] and/or more sensitive people (for example, toddlers, the elderly, and people with reduced immune defence) are simply more sensitive[61,65,39]. This is similar to sunbathing. People with particularly fair skin get sunburned more easily.

As with all dangerous substances, there are **clear regulations for the protection of human beings and the environment from ozone**. Regarding ozone, there are regulations in the area of occupational health and safety (for example, when welding)[172], environmental protection (for example, summer smog)[166,169,170,171,173] and safety of electrical devices for domestic use (for example, ozone from copiers & printers)[165]. The **limit values** for being harmless to health are **between 0.05 ppm**[171,165] **and 0.07 ppm**[170]. The **duration of effect also plays a role in the regulations**. For details, see Question 54, Page 35.

In order to get a **"feeling for the degree of danger"** of concentrations and the duration of effect (exposure), those of the EU directive are[166] listed below. Note the duration of effect.

- The **long-term target** value is a value for "effective **protection of human health** and the environment, which must be observed in the long term"
  - **Concentration: below 0.06 ppm**
  - **Exposure: not more than 8 hours above 0.06 ppm**

- The **information** threshold is a value above which there is a "risk to human health for particularly sensitive population groups and at which appropriate information is required immediately"
    - Concentration: at least 0.09 ppm
    - Exposure: at least one hour
- The **alarm threshold** is a value above which there is a "risk to the health of the population as a whole and at which the Member States must take immediate action"
    - Concentration: at least 0.12 ppm
    - Exposure: at least one hour

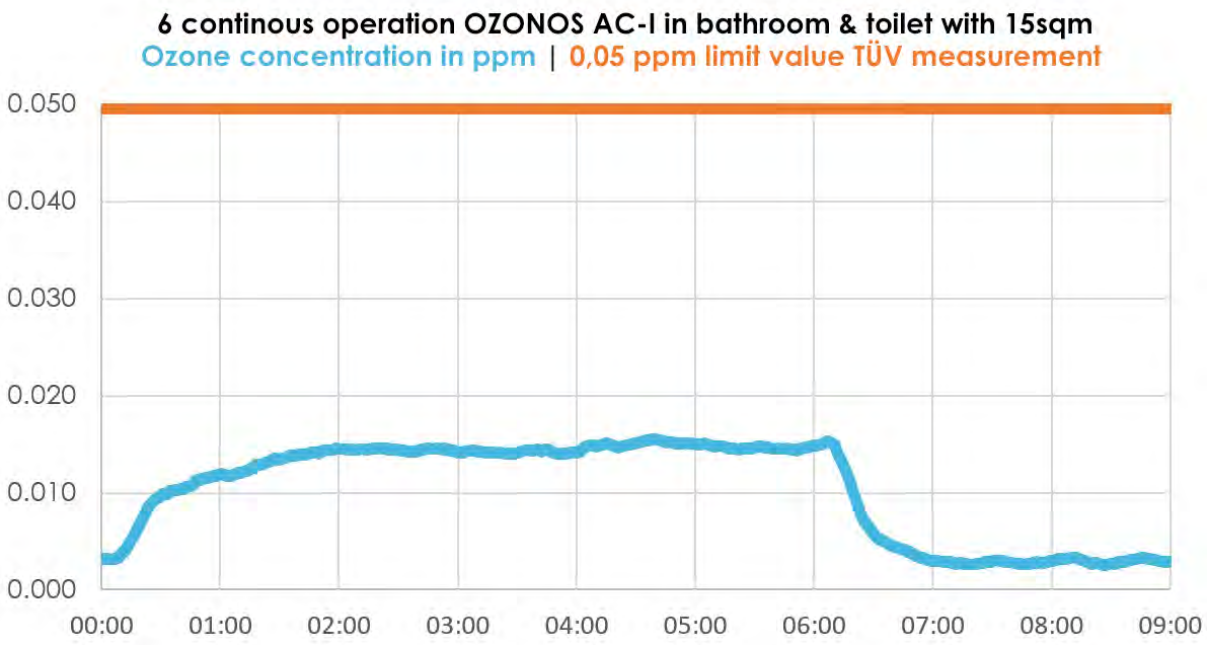
It is of **great concern** to the manufacturer that the OZONOS AC-1 in continuous operation, that under unfavourable conditions and directly at **the device, does not exceed the lowest prescribed limit of 0.05 ppm.** In this case, it is the limit value of the EN60335-2-65 standard[165]. TÜV Süd also checked the test: "The test results[66] show that the product presented meets the requirements of the specified test requirements."[67] In addition, **each built-in UV-C lamp is checked** to ensure it does not generate more ozone than specified.

In continuous operation, the OZONOS AC-1 generates less than 0.05 ppm directly at the device under the most unfavourable conditions.

Furthermore: the ozone concentration in the room is lower. The ozone spreads and decomposes faster because of the impurities. The duration of the application is usually shorter than many hours.

Therefore, the actual concentration is less than 0.05 ppm and the exposure is less than 8 hours. That means that the EU directive provides protection for health. EN60335-2-65 is also complied with.

The following illustration can be used for comparison. The OZONOS AC-1 was used continuously in a clean **bathroom & toilet** of approximately **15 m³** (approximately **6.5** m²),[180]. In the **6 hours** the ozone concentration rises to approximately **0.015 ppm** (measured at head height). The limit value of 0.05 ppm was far from being reached.



Another **measurement under realistic conditions** showed[180]:

- **"Cooking" scenario**: The **OZONOS AC-1 PLUS** did not exceed **0.035 ppm** in a 4-hour test operation in a kitchen of 72 m³ volume (approximately 30 m²) and **stabilised at 0.012 ppm**. The increase in the ozone concentration was stopped immediately when cooking started. (Details, see Question 48, Page 30)

As OZONOS products produce significantly less ozone than ozone generators, it is important to note that:

The OZONOS must not be confused with ozone generators and other technologies!

Ozone generators work with a completely different technology. For details, see Question 14, Page 16. They **emit** many **times more ozone** and produce the **additionally harmful nitrogen dioxide NO_2**[37]. These devices do not ensure compliance with the limit values! No device was found that was certified and complies with the standard for the safety of electrical[165] devices. Therefore, the manufacturers warn against an application in rooms where human beings are present. There are also many warnings about the use of ozone generators as air purifiers[68], whereby especially asthmatics have to be careful[69]. Upon closer examination, these warnings relate to ozone generators. There is no critical discussion of ozone concentrations in the studies.

12. What is ozone already used for today and where?

Practically all areas of application have something to do with **cleaning, hygiene, sterilisation, disinfection or odour control** in[70] air or[71,72] water. However, the range of application areas is impressive. With a few exceptions, most areas of application are **in the industrial and commercial sectors**[73]:

- **Drinking water treatment**
- **Water treatment**: whirlpools, swimming pools and aquacultures etc.
- **Wastewater treatment**: the textile industry, the pharmaceutical industry and wastewater treatment plants, etc.
- **Room air purification**: air disinfection, removal of volatile organic compounds (VOC), for example, in clean rooms
- **Odour neutralisation**: fire, smoke, cigarette and corpse odour etc. in rooms or for vehicles, biogas systems, waste management systems, rooms for waste, fat separators, fermenters and exhaust gas cleaning systems
- **Renovation** of rooms: mould remediation and odour control
- **Disinfection** of objects, surfaces, rooms or in washing machines
- **Production systems cleaning**: rinsing and cleaning of production systems, aroma substance removal, cleaning of reusable bottles as well as hygiene measures in the beverage and food industry (dairies, breweries, etc.)
- **Bleaching** of paper and textiles
- Deionisation of water: for example, rinsing water in the semiconductor industry
- Ozone in medicine: diverse applications[74]
- Cosmetics: vapour treatment of skin for cleaning[75] for example, acne (controversial[76])
- Ozone therapy: therapy method in alternative medicine[77] (controversial [74,78,79,80])

THE OZONOS AIRCLEANER

13. What is the OZONOS Aircleaner?

The OZONOS Aircleaner 1, or OZONOS AC-1 for short, is a **stylish**, **quiet and flexible ozone fan** or air purification device **for domestic use or** for **the commercial sector**. The cleaning effect is generated by the ozone generated. The **ozone is generated** by a **UV-C lamp** and distributed in the room by a fan.

The **oxidative effect** of ozone especially neutralises **odours**, such as, for example, paint, domestic animal, **kitchen, and cigarette odours.** The combination of **ozone and UV-C light** additionally works **against germs**, bacteria, viruses and mould spores. See Question 3, Page 6.

The special thing about OZONOS is that the **natural formation of ozone** is copied by solar radiation. The UV-C light in combination with oxygen generates ozone – only ozone! This method does not generate **any harmful nitrogen** oxides, such as those generated by "competing" ozone generators. The UV-C light also generates far less ozone than the ozone generators (see Question 14, Page 16). This means that the OZONOS **can also be used in rooms** where **human beings and animals reside**.

The corresponding standard[165] for household devices is complied with by the OZONOS AC-1. TÜV Süd also checked and confirmed this: "The test results[66] show that the product presented meets the requirements of the specified test requirements."[67]

14. How does the OZONOS Aircleaner differ from ozone generators?

Just like other commercially available ozone generators, the OZONOS generates ozone for cleaning. Nevertheless, there is an **essential difference**.

The **OZONOS** generates the ozone as in the ozone layer **using UV-C radiation**[1,30]. **Ozone** generators generate ozone **using high voltage**[32]. See also Question 4, Page 7. This gives the OZONOS two major advantages:

- **UV-C radiation generates** far **less ozone** than high-voltage discharges. The **limit values** for being harmless to health can be **complied with** in a much more stable manner in closed rooms.
- The **high-voltage discharges in ozone generators generate** in addition to ozone also ionised air and **toxic nitrogen oxides** NO_x[81]. The latter are air pollutants and are useless **for air purification and are harmful to health**.

Application: Today **ozone generators** are used very successfully in the commercial application area. However, if there are **human beings or animals in the room**, they **cannot be** used. A typical **ozone generator** usually generates more than **1000 mg/h**[82] (milligrams of ozone per hour) and the ozone concentrations are difficult to control[68]. In **contrast, the OZONOS AC-1** generates **2.5 mg/h**, AC-1 PLUS and PRO 6.0 12.0 mg/h.

Product: **Ozone generators** vary from **small, portable devices** to **large, permanently installed systems**. For the treatment of air, ozone devices are usually combined with air movers in order to distribute the ozone as well as possible in the room. There are two further disadvantages here: as a rule, ozone generators are **louder** (> 40 db in contrast to < 40 db with OZONOS) and **look** very **similar to ugly** construction **fans**. They are therefore devices that you would not wish to have in your home given their look.

Functionality: **Ozone generators generate ozone using corona discharges**. This is **similar to a thunderstorm**[33,34]**, copier**[35] **or laser printer**[36]. High-voltage electrical discharges provide the energy to break down oxygen and generate ozone (see Question 4, Page 7). Unfortunately, other substances are broken down or generated with the high voltage. The **resulting toxic nitrogen oxides** NO_x and, subsequently, nitric acid[81] are an **unwanted, unhealthy and useless by-product** of the method. The problem can only be avoided if pure oxygen is used[81]. However, this would result in the need for an expensive and safety-critical consumable, namely oxygen in cylinders. Ozone **generators** therefore **are** not suitable **for home application**.

15. What are ionisation devices?

Ionisation devices ionise the air. That is, they **charge** different **particles of the air negatively or positively** (an ion is a charged particle)[83,93,42]. Why do they do that?

Filtering[84,85,42]: On **the one hand, because it causes "floating" particles** (mostly dust) to be **charged**. These particles can **then** be **electrostatically removed** with oppositely charged filters – similar to metal chips and a magnet. Ionisation devices without additional technology remove very small particles, such as those in tobacco smoke, **but they do not remove odours or bacteria, etc**. In addition, the larger the particles, the less effective the method. The majority of the removed particles are not visible to the human eye. This corresponds approximately to the known fine dust (PM10)[86]. The **filtering of fine dust** is a **good thing**, as it is classified as harmful to health[87].

Positive effect: On the other hand, ionisation devices are used **to specifically release negatively charged particles** (= negative ions, **negative air ions**, NAI) into the **ambient air**. Negative ions have recently been **hyped as health promoting**[88,42]. For example, it is believed that the negative ions are the reason

why a **walk**[41] in the woods or staying **near a waterfall**[40] has a positive impact on health. The proportion of negative ions is particularly high at these locations. Initial scientific studies document the connection between negative ions and the positive effect but are not scientifically clear.[42]

What does that have to do with ozone? **The artificial generation of ions** usually takes place using high voltage[42], that is, the **same as for ozone** generators (see Question14, Page 16). That means that they generate ozone[89]. However, it depends on the technology used and the operating voltage whether ozone and nitrogen oxides are generated. The specified operating voltages fluctuate between 1.5 kV (kilovolts) and 16 kV[90,91,92]. **This is often kept silent in order to distract from the ozone generated**. For marketing reasons, however, the devices are sold as ionisation devices. However, they are ozone generators. Ionisation is a side effect of ionisation devices. The coronary discharges naturally also produce the toxic nitrogen dioxides[37,93]. Some ionisation devices try[83] to minimise the amount of ozone and nitrogen oxide (activated carbon filter) emitted by additional technology so that they can also be used for home use. In short, the **big disadvantage of ionising devices** compared to the OZONOS:

- either they generate **none or too much ozone/nitrogen dioxide**
- if **the ozone is lacking**, there is **no elimination of odours, germs, bacteria or viruses, etc.**
- **additional filters**, for example, activated carbon filters, **are a consumable**

Only ozone has a comprehensive cleaning effect through oxidation and only the patented method of the OZONOS Aircleaner **supplies ozone in quantities that are harmless to health**.

16. How does OZONOS differ from HEPA filters?

Ozone or the OZONOS **does not filter anything**. A HEPA filter (**HEPA** = High Efficiency Particulate Air Filter) filters the air by the device pushing the air through a membrane or a filter. **Particles** up to a diameter of **0.3 micrometres** (µm) **are filtered to** 99.97%[94]. All gaseous substances remain in the air. The HEPA filter is of course a consumable and must be replaced. In addition, germs can settle in the filters themselves and contaminate the air again[5].

Air purification with ozone works differently. **Ozone oxidises** the substances in the air. The **substances** are **changed or decomposed**. However, they are **not filtered out**. See on this, Question 3, Page 6.

17. How and where can you use the OZONOS Aircleaner?

See the Question Block Areas of application from Page 19.

AREAS OF APPLICATION

18. What application examples are there for the OZONOS?

The **OZONOS Aircleaner** can be used **wherever** bad odours and air impurities and/or germs, **bacteria, viruses, fungi, spores, pollen and allergens** make **staying in the room unpleasant**. Due to the low levels of ozone generated, it is designed **for** deployment in **inhabited rooms**. It is not suitable for industrial application, for example, in production systems.

Specifically, the following application examples make sense:

- Apartments
- Fire damage
- Water damage
- Driver compartments of cars, trucks
- Beauty salons
- Chemical cleaners
- Fitness centres, gyms
- Changing-room
- Food storage places
- Funeral parlours
- Rooms for refuse
- Hotels, hotel rooms
- Animal shelters
- Sanitary rooms
- Sewer odours
- Office buildings
- Pet shops
- Restaurants, bars
- Schools
- Swimming pools
- and many more

19. What does ozone remove?

An incredible amount of things! Ozone removes by oxidation from the air (see Question 3, Page 6)[5,10]:

- **Odours**[10]: smoke[101,102,103], refuse, fish, sanitary, sewer, mould, sweat and pet odour
- **Cooking odours**[105,106]: grease, proteins, organic acids and compounds[6,7,8,9,10,105,106]
- **Harmful vapours**: hydrogen sulphide ("rotten egg smell"[95];), volatile organic compounds (VOC)[11,12,10,13,14] etc.
- **Causes of illnesses**[18,19,20,21,71]: germs, bacteria, viruses, fungi, yeasts or mould carried into the air, if only to a limited extent.

For details, see also Question 3, Page 6. In addition, ozone also works when the particles or germs are on surfaces, although not as efficiently[20].

What ozone does not do:

- **Ozone does not filter**. Particles suspended in the air, for example, dust particles, fine dust or soot, remain in the air. See Question 16, Page 18.
- **Clean air remains clean air**. Ozone does not react with the natural components in the air. See on this, also Question 3, Page 6.

20. Does industry use ozone for cleaning?

Yes! Ozone has been cleaning air[70] and water[71,72] for many years already!

In the industrial and commercial sector, ozone is a common method of **treating exhaust gases, exhaust air and waste water with ozone**[73,96,97]. Fibreglass factories, paint factories, food processing plants, the textile industry, the pharmaceutical industry, the petroleum industry and the waste management sector can use ozone for cleaning.

For further possible applications see Question 12, Page 15.

21. For which allergies can the OZONOS be helpful?

A very good question. The manufacturer's own tests suggest that the OZONOS can be helpful for **pollen, animal hair or** house dust mite allergies and it reduces the allergic reactions. It is believed that **ozone deactivates the allergens (proteins) on the surfaces**, that trigger the allergic reactions in the body.

Scientific **studies** have not **been found**. The **topic of** "ozone and allergies" is **very sensitive**[64,68,69,100], because:

1. **Ozone affects** plant growth in the open air as an environmental pollutant during **summer smog**. Plants respond to ozone pollution by producing more allergens[9899].
2. **Ozone** is particularly **problematic for allergy sufferers and asthmatics**, as these human beings are much more sensitive to ozone concentrations[64,69,100].

The **OZONOS produces** with its UV-C method **significantly less ozone** than the branded ozone generators[68,69,100] (see Question 14, Page 16). The **studies and warnings found are therefore not applicable**. The critical discussion about ozone concentrations is lacking or the distinction between the ozone generation methods.

Ozone cannot eliminate food intolerance. Ozone only works on allergens that are spread through the air.

22. Can the OZONOS be used in boats, cars and cellars?

Yes! See Question 23, Page 21.

23. Can ozone remove fusty, musty or mouldy odours?

Yes! Ozone works particularly well with a musty odour. Ozone also works if the causes of this odour are **old textiles, old furniture** or **damp basements**. For details, see Question 39, Page 26.

The OZONOS **cannot fight the cause of damp cellars and mould**. A damp cellar will repeatedly affect the room air, since the bacteria and mould that thrive in it continuously release odours into the air.[136]

See also Question 26, Page 21.

24. Can cigarette odour be removed from a car?

Yes! Ozone permanently and completely **destroys the odour of cigarettes in cars**[101].

Due to the size of a vehicle compartment, you should **never be in the vehicle during** application. The windows and doors must be kept closed.

25. Can cigarette odour be removed from rooms?

Yes! Ozone destroys the cigarette odour in rooms, for example in hotel rooms, **sustainably and completely**[102,103]. See also Question 26, Page 21.

However, **the** OZONOS products are **not for rooms** where human beings have been **smoking for years** (bar, smoker's living room, etc.). For this, professional cleaning, swapping carpets and painting is essential.

For the application, an **Intensive ventilation is recommended before and after the treatment**. Moreover, **during the application, you must not be in the room**.

26. Can mould odour be removed from rooms?

Yes! The odours are permanently removed from rooms, for example, hotel rooms. The prerequisite for this is, of course, that the odours are not produced again and the causes of the mould are eliminated. A **very significant improvement in air quality is achieved for indoor air**. For details, see Question 39, Page 26.

Assume the room is 4.0 m x 5.0 m x 2.5 m or 50 m³ in size, then, according to the **manufacturer**, it takes an average of about 15 to 45 minutes to neutralise the odours in this room with an OZONOS Aircleaner.

If there **is a strong mould infestation or a strong odour of mould** or mildew, **a specialist must be consulted**. It depends very much on the existing types of mould, fungus and bacteria as to whether they also release harmful (toxic) metabolic products and cell components into the air. The unpleasant odour is currently considered to be harmless.[136]

27. Does ozone work in the presence of odours in walls and floors?

Yes! However, **cleaning takes** longer **than with odours in the air**. Ozone has the property of combining with odour molecules fixed in carpets, walls, etc. if it can penetrate these materials. Ozone generators are used for precisely this application[104]. The OZONOS products generate a much lower ozone concentration, which extends the treatment time. Therefore, **for** a **professional restoration** of rooms with bad odours, **professional cleaning** is to be preferred.

Intensive cleaning with an OZONOS **AC-1 PLUS or PRO** is necessary for heavily contaminated rooms. **Staying in rooms** during a long treatment must be **avoided**.

28. Can ozone clean kitchen air?

Yes! Ozone is already used for this purpose in commercial kitchens[105,106]. This is even a **prime example of** the use of **ozone as an air purifier**. There are many unpleasant odours in kitchens. These odours must be removed before they are released to the outside.

29. Can ozone be used in a laundry?

Yes! Ozone can **remove musty, body and mould odours from textiles and has a disinfectant effect**. Ozone has the same advantages in water as in air: it eliminates odours, germs and has a cleaning effect[107]. Numerous laundries use it to advertise[108,109]. There are also modern washing machines that release ozone into the wash water to disinfect textiles while washing[110]. This fact is not noticeable because "active oxygen" is usually used instead of "ozone"[111].

30. What is behind the sick building syndrome?

Since the **1990s,** Sick **Building Syndrome (SBS)** has become an increasingly discussed topic[112,113,114,115]. Rooms with **sealed windows** prevent the exchange of

fresh air. The **heating dries the air**. Poorly installed, **bacteria-contaminated air conditioning/ventilation** systems contribute to an **increasingly poor air quality** in buildings[115].

The result is stale **air in which you somehow feel uncomfortable, depressed or dull**. Among other things, the ability to concentrate is lost or one gets tired[115]. Research has therefore been conducted on the topic of indoor air quality (IAQ) for some time.

The American environmental authority, the United States Environmental Protection Agency (EPA), has been publishing for some time **reports concerning indoor air quality**[116]. Americans spend an average of **approximately 87% of their time indoors**[117]. The air quality in buildings is therefore an important factor for health. Firstly, human beings are in buildings longer than in the open air, secondly, other **artificial sources** are added to normal air pollutants[118], for example, **perspiration** from furniture and carpets. The **potential for improving** indoor air quality is therefore **huge** and necessary[119].

31. Does ozone help a sick building?

A **sick building** is caused by **rooms that are too tightly sealed**. Odours, bacteria, vapours (for example, formaldehyde from furniture), dry air, smoke and carbon dioxide build up due **to insufficient fresh air exchange** and cause a health hazard. **Poorly** installed or **maintained air conditioning systems** do the rest. For details on the sick building syndrome see Question 30, Page 22.

So yes! Ozone can help here by **improving air quality** and, **above all, by reducing accumulated odours**. It fights some symptoms and therefore has a positive effect on well-being in the rooms.

However, **ozone** or OZONOS **cannot solve all problems**. For example, it does not help against dry air and cannot filter anything (fine dust or pollen, etc.).

The cause of sick buildings, namely **poor ventilation** or **poorly** installed or **maintained air conditioning**, **cannot be eliminated by the OZONOS**.

32. Could ozone have prevented the 1976 Legionnaires' disease?

Probably, yes. In 1976, more than 182 human beings were infected with Legionella in a hotel in Philadelphia. It caused a kind of pneumonia. **29 human beings died as a result**. The cause was poorly maintained air conditioning.[120]

Ozone is used today, among other things, for **cleaning and disinfecting systems of all** kinds, for example for treating supply and exhaust air and also for air conditioning systems[121]. In this case too, this would have helped to disinfect the air

conditioning system. Here, ozone acts **against biofilms, fungi and mould**, that settle in the systems.

This tragic incident has helped to characterise the sick building syndrome[115]. Since then, the **attention of the environmental authorities** has shifted more and more **to** the **quality of indoor air** and well-being in rooms. See Question 30, Page 22 and Question 31, Page 23.

33. Is ozone used for food storage and preservation?

Yes! Ozone was probably first used in 1909 to sterilise food in Cologne, France[122,15]. In this use, ozone is very effective in **extending the shelf life** of foods[123]. For example for sterilised ice cubes (fish storage), room air treatment in cold rooms, prevention of germ growth in cooling devices as well as treatment of water for washing fruits, vegetables and meat[124]. Ozone is mainly used to treat the **food directly**, to treat the **surrounding air** or the **equipment used** or to protect the food from **unwanted odours** or tastes[125,124]. In addition, ozone is used to control the ageing of cheese[126]. Ozone also protects food from unpleasant odours. The big advantage is that ozone leaves **no chemical residues**, no additional odours or tastes[125], and after a while it decomposes into oxygen[26].

34. Do foods last longer when exposed to ozone?

Yes! Ozone deactivates bacteria, fungi and mould in air, water and on surfaces or directly on food, in the surrounding air or on work surfaces. This enables elimination of the **most common reasons for food spoilage**.[123] See on this, Question 40, Page 26.

Some **foods** are **treated directly**, for example by washing with ozonised water, some are treated with **the surrounding air** during storage (cold room or protective atmosphere in packaging) or processing[125]. The killing off of bacteria, fungi and mould leads to a longer shelf life[123].

35. Is ozone used in the egg industry?

Yes! Ozone can be used to **reduce germs** on eggs[127,15]. However, alternative methods are also deployed. The outside of eggs is naturally populated with harmless and dangerous germs (for example, salmonella[128]) of all kinds. A freshly laid egg protects very well against these germs. The ozone is used relatively quickly after the eggs have been laid, either in gaseous form[127] or dissolved in water,[128] to reduce germs. This **prevents germs entering the egg on a longer storage** or germs entering the egg when cracked open.

36. Is meat treated with ozone?

Yes! Ozone is used for **meat, poultry and fish** in **gaseous form** as well as **when dissolved in** water[15]. The meat can be **treated directly**. However, ozone is also used to **clean production plants** or for **the treatment of indoor air**. However, a rancid taste can arise as ozone can react with the fats and fatty acids on the surface of the meat. Therefore, direct treatment with some types of meat is avoided.[129] See also Question 33, Page 24 and Question 34, Page 24.

37. Do greenhouses use ozone?

Yes! The application is very diverse[130]. In greenhouses, ozone is used for **the treatment of water**[131] and for the generation of **clean air**[132]. This ensures uniform growing under clean conditions. **Pests** can also **be** controlled[133]. Even the **earth** can be **treated** with ozone[134]. Sometimes ozone is to be found in use in exhaust **air purification** to remove the odour of **strong-smelling plants,** for example in cannabis plantations[135].

FUNCTIONALITY

38. What is ozone?

Ozone O_3 is a strongly **reactive form of oxygen** and consists of three oxygen atoms. It is a **natural part of our atmosphere and** in low concentrations, **also of our breathing air**.[2,3,1] For all details see Question 2, Page 5.

39. Why does ozone work with odours?

In **ozone** O_3 the **third oxygen atom** is only weakly bonded **to the other two**. It therefore separates **easily** from these in order to **combine** with **other substances**.[3]

Odours are molecules floating in the air (VOCs or fatty acids, etc.) that our nose can perceive as an odour. Ozone reacts with these molecules. The formation of this new compound is called **oxidation** or it is said that the molecule is oxidised. In this chemical process, **the odour molecule, as a rule, decomposes into odourless components**.[4]

For details, see Question 3, Page 6 and the illustration shown there.

Example mould and musty odour: An earthy, musty or mouldy odour **comes from** so-called **Actinobacteria** in **many cases**. These bacteria are typical companions of damp and mouldy environments and emit very intensely smelling **metabolic products** into the environment – the musty odour known to us. **Mould** also releases these substances into the room air. These substances are also called **volatile organic compounds** (**MVOC**, Microbial Volatile Organic Compounds). Human beings can smell MVOCs (for example, alcohols, terpenes, ketones, esters and aldehydes) in very small quantities and usually find them unpleasant. However, the odorants are not considered to be harmful to health.[136] The good thing is that ozone likes to react with these VOCs and neutralise them[11,12,10,13,14].

40. Why does ozone work on germs, bacteria, viruses, etc?

In **ozone** O_3 the **third oxygen atom** is only weakly bonded **to the other two**. It therefore separates **easily** from these in order to **combine** with **other substances**.[3]

Ozone **likes** very much to react **with albumen** (= proteins)[6,7,8] and **fats**[9,10] by oxidising them. This effect as a free radical[137] or as a cause of oxidative stress is fatal to germs, bacteria and viruses[20,21]. Basically all cells, including human, animal or plant cells. During the oxidation, the **proteins** are **changed**, so that they **lose their original function** and damage, destroy or **deactivate the cell**, depending on the type of change. For further details, see Question 3, Page 6. Specifically, ozone works in two ways[15,16,]:

Firstly, proteins and fats **are built not only into the outer skin** (cell membrane) of germs**,** bacteria or fungi (cell membrane)[18], viruses (capsid) and spores (sporoderm) **but also onto the surface of many allergens (dust mite droppings and animal hair)**. **Ozone** can **react** directly **with** these proteins **or fats**[15,22,18,138]. In the worst case, this can result in a hole in the membrane or the protein losing its function[18]. The cell dies off or is **deactivated**[15,18].

Secondly: Ozone can also **penetrate the cell**[16] and cause oxidative stress inside. In this case, it **oxidises** with a protein inside the cell, for example, with the **genetic material**[8], DNA[139] or RNA[23]. The cell can **lose its ability to reproduce**, die or become deactivated. This mechanism has not yet been sufficiently well documented, since the effects can be very diverse. However, individual effects of ozone on cell-internal protein production have already been documented[140,141142].

41. Why are human beings, animals and plants better protected?

Ozone attacks all cells, including human cells! See on this, Question 40, Page 26. **The human being** is a multi-cellular organism and consists of approximately 37,000,000,000,000 cells (37 trillion)[143,144]. It **can** and must replace many **dead cells** again and **again**. For example, in the event of an injury. Germs, bacteria, viruses, spores, pollen each consist of only one "cell". The whole organism is "dead" if this "cell" is damaged or deactivated. **human beings, animals and plants are multi-cellular organisms** – a clear advantage.

The death of cells is a natural and important process in the body. It is estimated **that** every **second 1,000,000 cells** (1 million) die in our body **completely naturally**. The death of individual cells is therefore not uncommon. **The body must and can handle it very well**.[145]

The **barrier function of the skin**[146] is a well-functioning **protection against ozone** in low concentrations. First, there is a **layer of fat** (sebum)[43] on top of it and just below that a layer of **dead skin cells** (horny layer)[147]. The **ozone would first have** to **"eat through" the outer layer**, in order to first damage a living cell by oxidation. With every oxidation, however, the ozone is consumed. The ozone **levels of the** OZONOS are far **too low for this**.

The cells of the respiratory tract, eyes and mucous membranes **are less protected**[62,60,63]. If the concentration is too high[60,39], these **areas will be irritated first**[61]. That means small inflammations develop, for example, a reddened eye. As long as the **concentration** of ozone **is** low, **the body can deal with these irritations very well**. The **body can replace a single cell**. There is **no permanent damage**.

One can imagine **the** irritation **caused** by ozone **as being similar** to when a **splash of lemon juice gets** into **the** eye. Citric acid has a burning effect on the sensitive cornea. The eye burns until the tear fluid has diluted the acid sufficiently. It may, **depending on the amount and duration of effect**[60,39], **cause brief reddening**. With the OZONOS AC-1, the concentrations of ozone (<0.05 ppm) are so low that there is no such irritation. However, if you practice sports in the summer smog for several hours at the highest warning level (> 0.12 ppm),[166] eye redness or irritation of the respiratory tract is to be expected.

Nevertheless, **ozone** is not without danger. It generates free radicals and exposes **every cell reached** to **oxidative stress**. This can be the cause of illnesses.[137]

Important: The **OZONOS AC-1 complies with the limit of 0.05 ppm** of the standard[165] **EN60335-2-65 for**[165] **household electrical devices**. As a result, the EU's higher limit value for being harmless to health will[166] not be exceeded.

42. What does oxidation mean and what is an example of it?

Oxidation is a **certain type of chemical reaction**[148]. For details, see Question 3, Page 6. The **ozone** molecule O_3 **releases an oxygen atom** O to another molecule (substance) **in the case of ozone**. The **substance thereby decomposes** into one or more other substances. **Ozone** is considered a very **strong oxidising agent**. That means it reacts very quickly with other substances in the manner just described.[61].

Other examples for oxidation: **to generate energy in the human body** food molecules in cells react with oxygen O_2 (absorbed through the air we breathe) and thus generate carbon dioxide CO_2 (released through the air we breathe), energy and heat[149]. Another example is **rust**, which arises from the oxidation of iron Fe with water H_2O[150].

43. How does the OZONOS produce ozone?

The OZONOS produces ozone **using UV-C** radiation[15,1]. This is exactly the **natural process**, that occurs naturally **in the ozone** layer[30]. This process happens inside the OZONOS products. The built-in UV-C light is the artificial sun[31] and provides the high-energy radiation that generates oxygen O_2 Ozon O_3. The advantage

of the patented method is that **there are no other (harmful) substances**, as is the case with ozone generators or corona discharges[15,32] for example[81,35,36].

For details on the types of ozone **formation** see Question 4, Page 7.

For details on **ozone generators** see Question 14, Page 16

For details on **ionisers** see Question 15, Page 17.

44. What does the 'C' mean in 'UV-C'?

UV radiation is **ultraviolet radiation**. This is electromagnetic radiation that is not visible to us human beings. It is shorter-wave (400 to 100 nanometres) than visible light. UV radiation is a natural component of the sun's radiation. The **UV radiation** is divided into **three** ranges: **A, B and C**. The **UV-C portion** covers the wavelength range from **280 to 100 nanometres**, radiation in this area having a particularly large amount of energy.[151]

45. How can ozone and chlorine be compared?

Chlorine and ozone are both used in **drinking and wastewater treatment as well as** in **pools** for disinfection[152,153,154]. The difference is, if the **chlorine** is not consumed by reactions, **it** remains **in the water**. **Ozon decomposes** over time into oxygen[26]. Chlorination therefore leaves the typical **chlorine taste and odour** that is known from some drinking water or from swimming pools. On the other hand, **ozone** decomposes **without residue**, provided that it has not been used for cleaning. It is more effective than chlorine[155] and less harmful to health. **Chlorine** is stored in gas cylinders, and when it leaks, it **is very dangerous**[156]. On the other hand, ozone is generated in a completely analogue manner for OZONOS using UV-C lamps in a closed pipe system. A leak is therefore also less likely.

46. What happens to the decomposing odours, bacteria and pollen, etc?

Germs, bacteria, viruses, pollen etc. as well as fats and proteins are **solid components or particles**. They float **in the air before and after**. The larger the particles and the calmer the air, the faster that these substances settle. Finer particles leave the room due to the **natural air exchange during ventilation**.

47. How can you determine yourself whether the OZONOS really works?

Possibility 1: Take a **wet towel**, let it **get** mouldy **or** use it until it gets **musty**. Then put it in a plastic bag and blow ozone into the plastic bag for about 20 minutes. You will see how well it works!

Possibility 2: Try soccer **shoes or running shoes**, that nobody dares to approach. Test the effectiveness in a small room such as a toilet. After a very short time you will find out how effective the application of ozone is.

48. Can you measure whether the OZONOS really works?

Indirectly – but you can smell it!

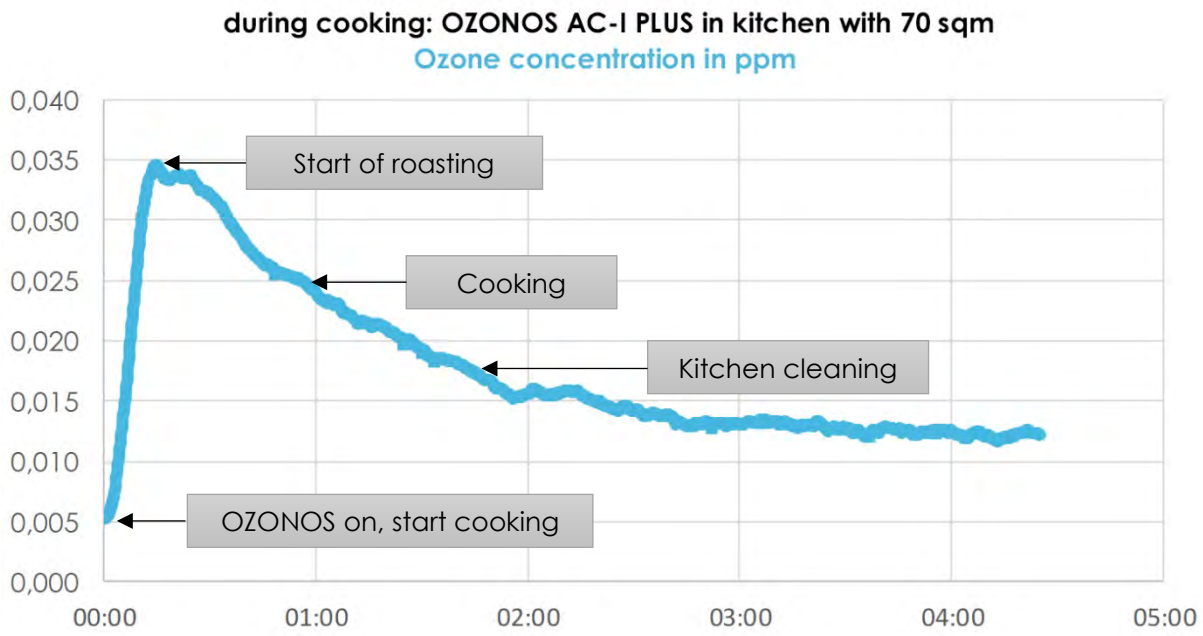
From a purely physical point of view, ozone decomposes completely in the presence of suitable reactants (odours or germs, etc.) and over time. The more reactants there are, the faster ozone decomposes through oxidation. In other words, if there are odours, etc., the ozone decomposes faster by doing its work. See on this, Question 3, Page 6. Therefore:

Assumption: The ozone concentration drops more quickly in polluted rooms or builds up more slowly (depending on the ratio of ozone generation and ozone depletion).

The ozone concentration in the room is measurable.

Prerequisite: The framework conditions, such as room temperature, air humidity, constant generation rate, etc., remain the same and do not additionally influence the raising or lowering of the ozone level.

Here is an example of odour neutralisation when cooking:



The illustration shows the course of the ozone concentration **during** the **cooking of a duck à l'orange without extractor fan and with the windows closed**. The starting point was a well-ventilated, clean kitchen. When **cooking started** the **OZONOS AC-1 PLUS was switched on** and the room closed. In the first 15 minutes, **the ozone value rises rapidly** during the **preparation time** as hardly any impurities are released into the room air. With the **start of roasting, odours** of **fat and roast** spread into the kitchen. Vegetables and spaetzle are cooked a little later. The **ozone reacts quickly with the odours**. Despite the fact that OZONOS is still switched on, the ozone concentration drops quickly and continuously. As a result, **the ozone concentration stabilises** at the relatively low level **of approximately 0.012 ppm**. Continuous odour removal is at work. A mathematical estimate (see Question 59, Page 40) of this state of equilibrium gives a **half-life time of a maximum of 7 minutes**. Compared to other measurements, this is relatively short – which was to be expected.

Another example is given in Question 59, Page 40.

The graphic clearly shows that the ozone "does something" as it decomposes much faster during cooking. Since the odour of cooking also reduces over time, **this** confirms **the function of the OZONOS**.

OZONE CONCENTRATION AND SAFETY

49. What is a concentration or ozone concentration?

In chemistry, the **mixing ratio of two substances** in a certain volume is given as a concentration[157]. The **ozone** concentrations given indicate what **proportion of ozone there is** in the **air** around us.

For **example**: There are about 100 grams of dissolved sugar in a litre of **cola** (corresponds to about 1000 grams)[158]. 100 grams of sugar contrast with 900 grams of liquid, flavours, etc. Cola therefore has approximately a **10 percent sugar concentration or 100,000 ppm sugar**.

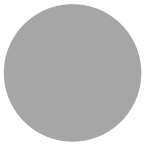
50. How does ozone form in nature?

Concerning the different types of ozone formation, see Question 4, Page 7.

51. What does ppm mean and how can it be imagined?

Ozone concentrations or general **concentrations can be given in ppm (= parts per million,** one **millionth, 1/1,000,000)**. A ppm describes a millionth part of a whole.[159] This is just one possible unit of specifying a concentration[157] of one substance in another. In general, **ppm describe very low concentrations**, that is, "practically nothing". It is therefore **difficult to imagine something**.

For **example,** the **area corresponds to this circle**



= 1 ppm of the tennis court

exactly one **millionth part of the area of a tennis court** (23.77 m x 10.97 m). Further 1 ppm examples: three drops in an average bath of 150 litres or a level teaspoon of salt in 1000 loaves of bread of 1 kg each.

Some human beings can smell ozone from as little as 0.0076 ppm[51]. In terms of the tennis court, this corresponds to this area

- = 0.0076 ppm from the tennis

These human beings could also taste far less than a pinch of salt spread over 1000 loaves of bread! This is very impressive compared to our eyesight.

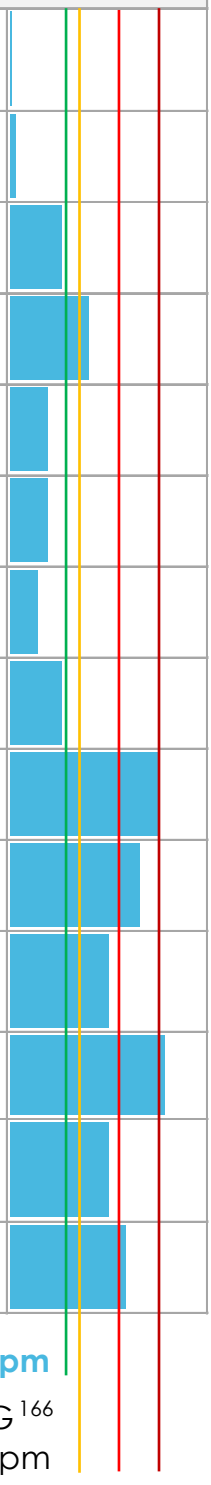
52. What are typical ozone concentrations which are encountered?

Ozone cannot be avoided. It practically surrounds us and is a **natural component of the atmosphere**. Even normal indoor air has a very low **basic ozone concentration**.[29]

The following table illustrates common ozone concentrations in our breathing air. It **compares typical ozone concentrations in our environment**[160,161,162,163,164]. The table shows that **in summer with summer smog,** the ozone values **often exceed the applicable limit values of the EU directive**. TÜV Süd confirmed this: "The test results[66] show that the product presented meets the requirements of the specified test requirements."[67]

Other maximum values: Compared to the **ozone layer**, these values are very low. At a height of 32 km there is a concentration of up to **8 ppm**[56]. On earth, **MIG welding** (AlSi 5) produces very high concentrations of up to **0.40 ppm**[164]. A respirator mask is mandatory.

Occurrence	Details	ppm
Basic concentration inside	Without interaction with outside air, average value of TÜV measurements for Germany	0,0017
Basic concentration inside	In common living spaces, average value from own measurements	0,0046
Basic concentration outside	Very clean air, winter with sunshine (Death Valley, USA) [29]	0,04
Basic concentration outside	Very clean air, summer with sunshine (Death Valley, USA) [29]	0,06
Average values Austria, outside	From 1993–2017, 54 measurement points [160(p. 87)]	0,0282
Average values Germany, outside	Rural, from 1995 – 2017 [163]	0,0285
Average values Austria, outside	Urban, from 1995 – 2017 [163]	0,021
Thunderstorm [34]		0,04
Summer smog Austria	Highest value, 2017, Vienna Lobau [160(p. 75)]	0,114
Summer smog Austria	Exceedances of the information threshold 2017, 23 measurement points for 11 days [160(p. 9)]	
Summer smog Austria	Excedances 0.06 ppm, 2017 46 Measurement points or 43% of the measurement points [160(p. 9)]	
Summer smog German	Highest value, 2017, Westeifel Wascheid [162(p. 5)]	0,119
Summer smog German	Excedances 0.06 ppm, 2017 236 measurement points or 94% of the measurment points [162(p. 7)]	
Printer, copier	Study, German Federal Environment Agency, 2009, maximum value for mass printing [35]	0,09



53. How can the different concentrations be converted?

The limit values for ozone are given in **different units in the different** regulations. For the **OZONOS** products, the **unit parts per million (ppm)** is used for concentration information (see Question 49, Page 32). The following table shows all[53] conversions.

		From				
		Parts per Billion	Parts per Million	Millilitres per cubic metre	Milligrams per cubic metre	Micrograms per cubic metre
		ppb	**ppm**	**ml/m³**	**mg/m³**	**µg/m³**
To	**ppb**	=	× 1000	× 1000	× 500	: 2
	ppm	: 1000	=	=	: 2	: 2000
	ml/m³	: 1000	=	=	: 2	: 2000
	mg/m³	: 500	× 2	× 2	=	: 1000
	µg/m³	× 2	× 2000	× 2000	× 1000	=

Example conversion for the blue coloured field: If you want to convert 0.05 ppm to mg/m³, the ppm value has to be multiplied by 2 (× 2). That means 0.05 ppm corresponds to 0.10 mg/m³.

54. What are the regulations for air quality with respect to ozone?

There are **a variety** of **national and international regulations for ozone**. They differ in their area of application:

- **Safety of consumer products**: regulates, among other things, the permissible maximum limits for released pollutants.
- **Environmental protection**: regulates, among other things, permitted concentrations of air pollutants in the open air.
- **Occupational health and safety**: regulates, among other things, permissible concentrations of pollutants in the work environment.

The regulations include **recommendations, guidelines, laws and standards**. They are issued by governments, international organisations or standardisation institutes.

The different regulations state **different limit values**. The **lowest**, that is, for health the safest **limit value**, is that of the **European standard EN60335-2-65 for electrical devices**[165] and the recommendation of the World Health Organisation, WHO[171]. The limit value is a maximum permissible value of 0.05 ppm ozone in

the ambient air. It should be noted here that the methods of determination are different. The limit value of the standard is the stricter and safer for health.

The main regulations for ozone presently, at the beginning of 2020 are:

Safety of products

EN60335-2-65 Safety of electrical devices for domestic use and similar purposes[165]	
Published by	European Committee for Standardization
Applicability	European Standard
Value	Limit value
	0.05 ppm

Environmental protection

EU directive 2008/50/EC166	
Published by	EU Commission, EU Parliament
Applicability	EU directive to be implemented in the national law of the Member States
Value	Target level for protection of human health
	0.06 ppm
Value	Information threshold (the authorities must inform the population)
	0.09 ppm
Value	Alert threshold (authorities must warn population)
	0.12 ppm
Value	Protection of vegetation, target value
	9.00 ppm
Value	Protection of vegetation, long-term goal
	3.00 ppm
Implementation Germany	Federal Immission Control Ordinance (39th BImSchV)[167]
Implementation Austria	Ozone Act, version of 17/06/2019[168]

Air pollution control ordinance LRV[169]	
Published by	Federal government
Applicability	Switzerland
Value	Limit value
	0.05 ppm

National Ambient Air Quality Standards (NAAQS) for Ozone 2015[170]	
Published by	United States Environmental Protection Agency EPA
Applicability	USA
Value	Primary Ozone Standard Level
	0.07 ppm

Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide[171]	
Published by	World Health Organization (WHO)
Applicability	Worldwide guideline
Value	Air Quality Guideline AQG for Ozone, limit value
	0.05 ppm

Occupational health and safety

List of MAK and BAT Values, Ozone, 1995*[172]	
Published by	German Research Foundation (DFG), Senate Commission for the Testing of Harmful Working Materials
Applicability	Germany
Value	Threshold limit value: daily mean
	0.10 ppm

* In the more recent Ordinance on Hazardous Substances GefStoffV 2005, Technical Rules for Hazardous Substances - TRHS 900, the value for ozone has not yet been specified. The older threshold limit value therefore still applies. Situation as of the end of 2019

Amendments to the Limit Value Ordinance 2011, Federal Law Gazette II 2018 No. 254[173]	
Published by	Federal government
Applicability	Austria
Value	Threshold limit value: daily mean | short-term value
	0.10 | 0.20 ppm

55. Which regulation is used at OZONOS and why?

For OZONOS, the **European standard EN60335-2-65 for the safety of electrical devices for domestic use and similar purposes**[165] is used. This standard is published by the European Committee for Standardisation and contains a limit value for ozone that must not be exceeded directly on the device.

With ozone-generating electrical devices (printers, copiers, and OZONOS etc.), safety is given according to this standard if the electrical device used does not exceed the **limit value of 0.05 ppm** under precisely defined conditions. This means that in the **immediate vicinity** of the electrical device, the ozone concentration in continuous operation must **not exceed 0.05 ppm**.

The **EN60335-2-65 standard was applied for three reasons**:

- The standard requires the **lowest permissible ozone concentration**. That means the standard offers the greatest safety. The most important regulations on environmental protection as well as on occupational health and safety are thus also complied with. For details, see Question 54, Page 35.
- The standard also specifies **very unfavourable conditions and a precise test procedure** for how and where the concentration is to be determined. That means that here, again, we are staying on the safe side.
- **Compliance**, and thus safety, **can be certified**. For the OZONOS AC-1, this was done by **TÜV** Süd[67].

56. How should the EU directive on environmental protection be understood?

Ozone is a **main component** of the so-called **summer smog**[39]. This is **where** the **misinterpretation begins**, because:

ozone is not a cause of smog but is itself the result.

Ozone is **not emitted from any car or chimney**. For the formation of ozone in summer smog, see Question 4 and 9, Pages 7 and 10. **The main cause of ground-level ozone** is the **nitrogen oxides** NO_x[39,174]. In 2016, in Germany, approximately **half came from traffic**. 78% of the traffic-related NO_x came from car and truck diesel engines[161]. The emissions scandal that became known in 2015 also revolved around high nitrogen oxide levels.[175].

In 2008, the EU has set, with the **EU directive 2008/50/EC for the protection of human beings and the environment**[166], many limit values for air pollutants. **Air quality monitoring stations** were set up in Member States[176] for monitoring. Their task is to measure the air quality constantly and to inform or warn the population when the limit values are exceeded.[176,177] Current measured values are published on the Internet[163,177] and reports appear annually. For ozone, the **the following EU limit values** have been set.

EU directive 2008/50/EC[166]	
0.06 ppm	Target level for protection of human health
0.09 ppm	Information threshold: the authorities must inform the population via the media Increased risk for particularly sensitive population groups
0.12 ppm	Alert threshold: the authorities must warn the population Risk for all population groups
3.00 ppm	Protection of vegetation, long-term goal
9.00 ppm	Protection of vegetation, target value

Switzerland is guided by these limit values[169]. 0.06 ppm also applies. In the USA, the target value of 0.07 ppm is[170] somewhat less stringent.

In Question 52, Page 33 some typical ozone concentrations are given. In **Central European cities,** and also in **rural areas** and in the **mountains,** the **0.06 ppm in summer can often not** be maintained. For example, in 2017, 236 (94% of the measuring points)[162] in Germany and 46 measuring points in Austria exceeded 0.06 ppm[160]. Even the information threshold was exceeded on 7 days in Germany and 11 days in Austria[160]. The alarm threshold was scarcely reached in Austria in 2017[160].

57. How long does ozone last and how quickly does ozone decompose?

Ozone is very **unstable** and does not last forever. It **either** reacts **immediately with suitable partners or decomposes** over time **on its own**. For details, see Question 3, Page 6.

The following factors promote or accelerate decomposition[26]:

- Higher **temperature**
- **Air movement**, drafts or fans, etc.
- Higher **humidity**
- **Presence of odours, harmful vapours, cooking residues and causes of illness** (bacteria or viruses etc.)

The decomposition rate for ozone can be given with the so-called **half-life** time[26]. The half-life time tells **how long it takes for half of the substance to decompose**[178]. For example: With a half-life time of one hour and an initial concentration of 0.05 ppm, the concentration drops to half after one hour, that is, to 0.025 ppm. After another hour, it drops to 0.0125 ppm, etc.

The **scientific literature contains** values **between a few minutes and a few hours**[26]. The scientific reference values were unsuitable for the assessment of the OZONOS products because they were measured either for water[179] or under laboratory conditions. For **determination of realistic half-life times** in "normal" living rooms, an **internal study**[180] was carried out with the three OZONOS models.

Half-life time	Scenarios
62 minutes	Scenario: **Unfavourable conditions** according to EN60335-2[165], measurements[66] of the certification[67]: – Temperature 25 °C – No air movement in the room – Airtight sealing of the room

	– Lining with PVC film – No impurities – Relative humidity around 50% (winter)
8 to 15 minutes	Scenario: **small room**, 15 m³, bath or toilet – Temperature 20-21 °C – No air movement in the room – Relative humidity at 60 - 65%
10 to 13 minutes	Scenario: **living room**, 90 m³, without additional load – Temperature 20 °C – No air movement in the room – Relative humidity at 62 - 65%

Times **between 8 and 15 minutes** can therefore be given as a **realistic half-life time in living rooms**. Ozone **decomposes** in normal living rooms about **4 to 8 times faster than** in a very clean, sealed and lined room.

58. Can the ozone concentration in a room be exactly calculated?

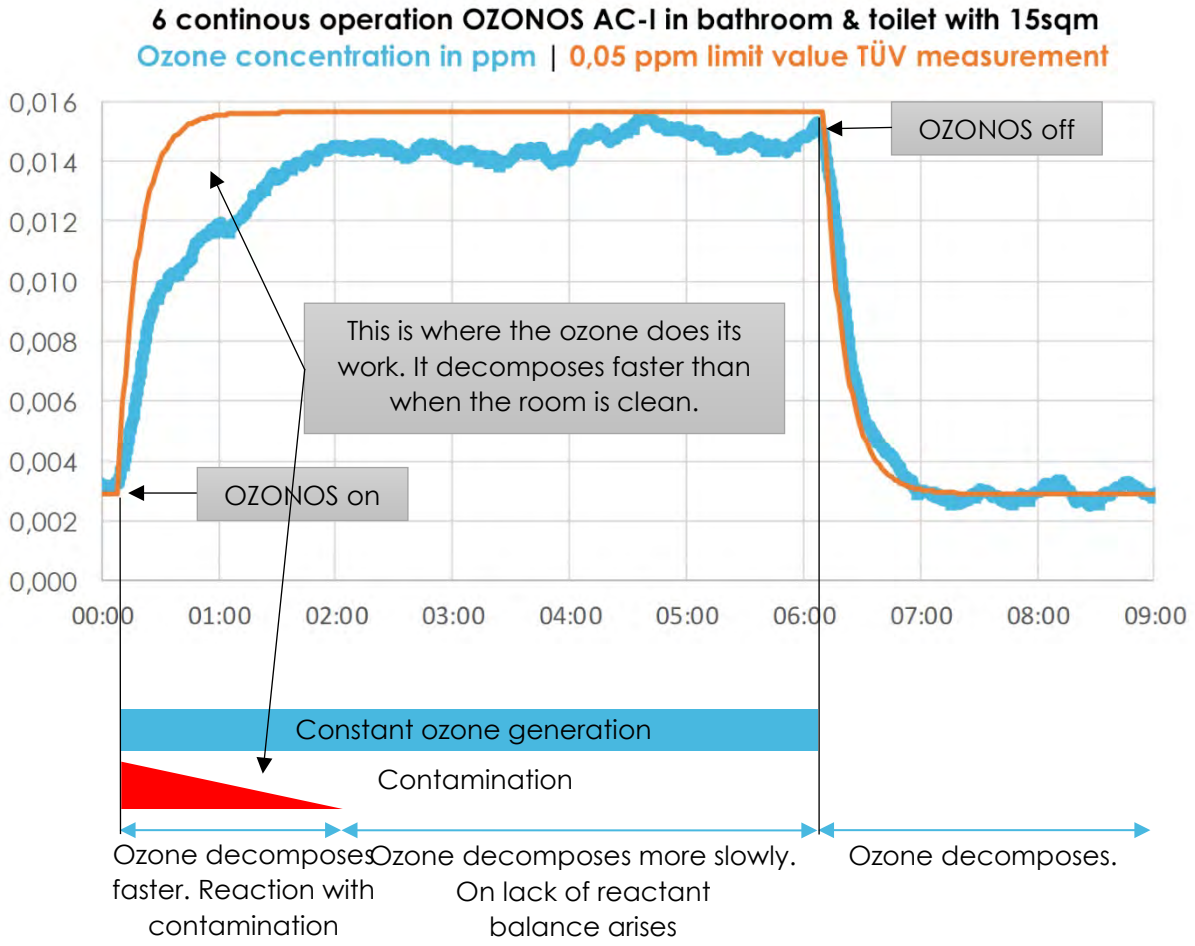
No. **No model was found** with the necessary **scientific accuracy** that **chemists like to have**. It is probably not possible either. An inhabited room with all of its environmental influences, materials, dirt or air circulation cannot be described with physico-chemical formulas. It is **too complex**, even for today.

Basically it does **not matter**. With the experienced **support of the manufacturers and common sense**, the OZONOS products can be **used without hesitation**. Nobody has to overly worry about concentration or formulas. OZONOS products are **just as "complicated" as an iron**. You can burn yourself but everyone knows that and can handle it and no one overly worries about a possible danger. The iron is just used.

59. Can you estimate the ozone concentration in a room?

Yes. On the one hand, the **ozone is constantly generated by the OZONOS**. On the other hand, the **ozone decomposes and/or reacts** as soon as it is generated. Since the generation rate for UV-C lamps is constant and very low, there is a **balance between generation and decomposition** after some time. From this point on, the ozone concentration in the room changes only slightly and is therefore stable. **After** switching **off** the device, **the ozone concentration in the room falls back to the basic concentration**. With the help of the generation rate and the half-life time (see Question 57, Page 39) it is possible to mathematically estimate the concentration in the closed room.[180,181]

For this purpose, realistic decomposition rates[180] **were determined in an internal study from measurements in typical living rooms**. The generation rates are known from the manufacturer of the UV-C lamps. Both are used to obtain an **estimate of the expected maximum concentration**.



In the **example given**, a constant decomposition rate of approximately 7.5 minutes was assumed. However, the **constant decomposition rate** is unrealistic for the calculation. It can be clearly seen that the **calculated concentration** (orange line) increases much faster **compared** to the **actually measured concentration** (blue line). This is because **at the beginning** the ozone does its work and **due to the pollution it decomposes faster** than at the end when the room is clean. A constant rate of decomposition only sets in after the work is done. Therefore, **the remaining development agrees well** with the assumed decomposition rate of **7.5 minutes**. After approximately 2 hours, an **equilibrium is established at approximately 0.015 ppm**. This value can be easily estimated using formulas and represents the maximum ozone concentration that can be achieved when the room is clean.

For the OZONOS products, it is therefore possible to roughly estimate the maximum concentrations that can be reached in rooms.

Both the measurements and the calculations have confirmed this behaviour. Furthermore, for **every situation** (room size, OZONOS model, assumed decomposition rate) a **theoretical "maximum" ozone** concentration that cannot be exceeded can **be mathematically estimated**.

60. Does the ozone concentration fluctuate with room temperature?

Yes, but this is negligible. Ozone decomposes more easily in warmer and more humid rooms before it reacts with other substances. Therefore, **the warmer and wetter, the less effective the OZONOS is**. In a normal room climate (20 - 25 ° C and 40 - 60% relative humidity), the **fluctuations are negligible**.[26]

61. What happens to ozone after it has served its purpose?

It decomposes – one way or another. **Either by "doing its work" or on its own**. Ozone is a very unstable and reactive substance. The third oxygen atom is only weakly bound and quickly forms a bond. The residue, the two remaining oxygen atoms, is molecular oxygen O_2. For more details on chemistry, see Question 3, Page 6.

62. At what concentration can ozone be smelt?

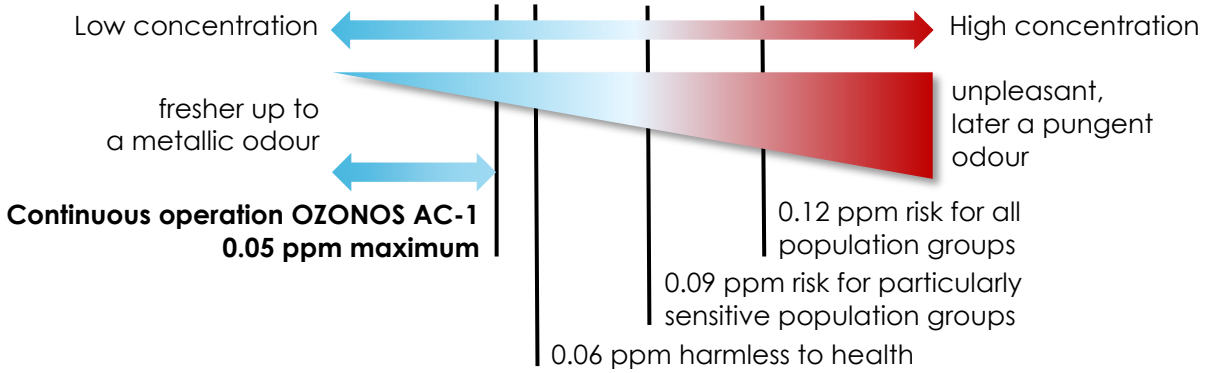
Between 0.0076 and 0.03 ppm[51,52]. A particularly **sensitive human nose** can perceive ozone as **a fresh, metallic odour from a concentration of 0.0076 ppm**. **Everyone should be able to smell** it at 0.03 ppm **at the most**.

More details are shown in Question 8, Page 9.

63. What does ozone smell like?

Ozone has a **very characteristic fresh**[3], **possibly metallic, odour**. The odour is described as **hay, clove, chlorine or**nitrogen-like[49]. In low concentrations, this odour is **not unpleasant**. A careful odour test on the OZONOS is not harmful. The characteristic **odour** associated with ozone can sometimes be felt right **after a thunderstorm**[33,34]. It is also associated with the odour of **freshly washed bed linen**. Ozone is also generated in the vicinity of **photocopiers**[35], **printers**[36], **electric motors or when welding**[164]. These ozone odours are often distorted by other odours (printing ink or lubricants).

Indoors, **ozone concentrations** over **0.06 ppm slowly smell unpleasant**. **From 0.10 ppm,** the odour is **unpleasant** and can be **slightly** pungent. You would not wish to be in the room any longer. The pure odour of ozone is subject to a habituation effect[54]. That is, after a while we start to notice that the odour is not as intense. However, the pungent or unpleasant effect is not affected.



If you compare these properties with the limit values of the EU directive[166], one thing is immediately apparent: **the sense of smell provides very reliable protection against long periods in rooms with increased ozone concentrations**.

64. What is the residual odour after the treatment?

After the treatment, **a kind of fresh**[3] **smell** can remain in the room, similar to that after a thunderstorm. This is **residual ozone** and a sign that the ozone cannot find anything more to remove. **The room is clean!** The OZONOS should now be switched off.

Especially in textiles and carpets, the ozone can still be retained. However, the **ozone will rapidly** decompose after the OZONOS **is switched off**[26,180]. A realistic half-life time is 15 minutes[181]. See on this, Question 57, Page 39. The **concentrations** are harmless when the device is **used properly**. If the odour is disturbing or unpleasant, you can always ventilate the space.

A slightly **sweet and** easily **perceptible** odour **may remain** after a longer intensive cleaning. A brief **ventilation** will remedy this.

65. What can you do if you suspect excessive concentration?

With professional and normal use of the OZONOS AC-1, **no ozone** concentrations can be reached **that are harmful to health**. The room can **always be entered briefly without hesitation**. Even the warning levels of the authorities (0.09 and 0.12 ppm)[166] in the case of summer smog only mean that you are not to spend too long in the open air. A good indicator for indoor rooms is the odour of ozone (see Question 63, Page 42).

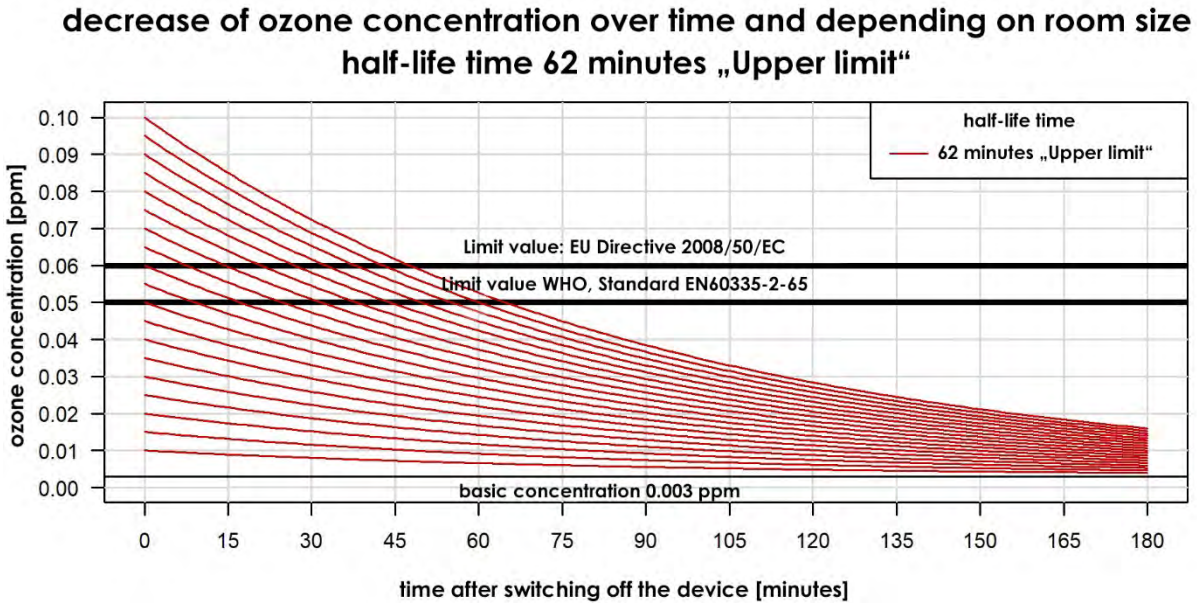
If you **still have concerns** that the concentration of ozone is too high in a room, then **two simple things help: air exchange and time**.

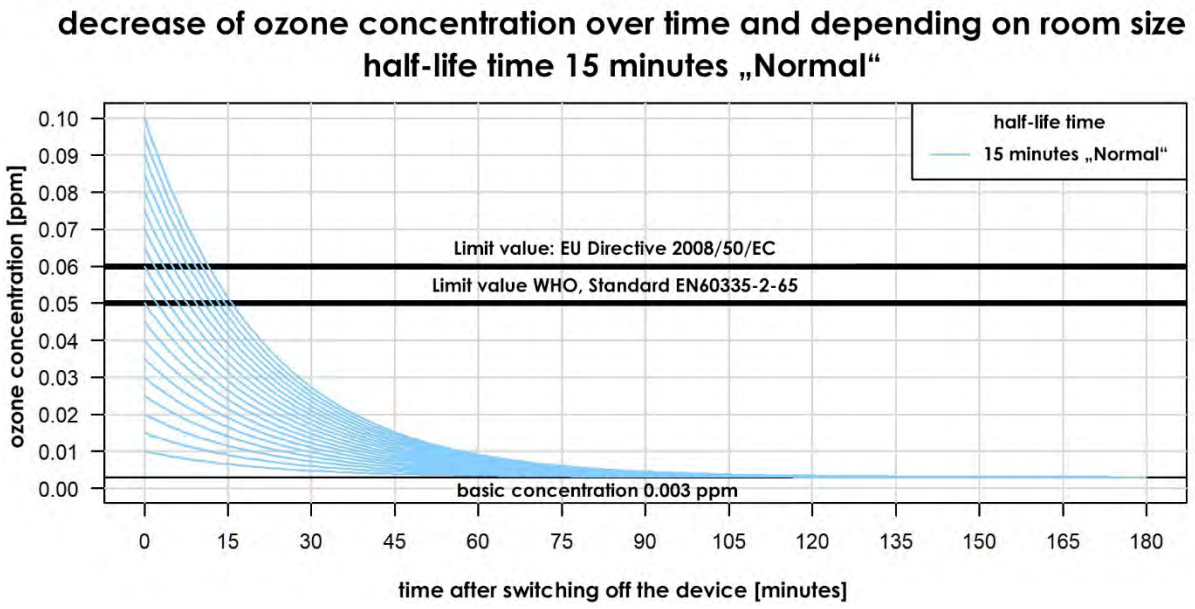
Specifically, you can safely do the following:

- Switch off the device, close the door and do not enter the room for about an hour.
- Switch off the device and open the window for ventilation.
- Switch off the device and open the door to the room.

After switching off the device, it takes **approximately one hour**, in closed rooms under unfavourable conditions, until the **ozone concentration halves**. 15 minutes is more realistic (see Question 57, Page 39)[180]. An example of this is given in Question 59, Page 40. The following graphs illustrate this again using a theoretical model calculation.

If you use the device in particularly **small and closed rooms**, for example in a driver's compartment, a small boat or a small toilet, you should**avoid** staying **in the location**. Staying in the room should also be avoided on intensive cleaning.





66. Can the OZONOS consume too much oxygen?

No. Since the OZONOS only produces very small amounts of ozone from oxygen, the **oxygen content in the air being not affected even after a long treatment**. Every human being uses tens of times more oxygen than the OZONOS.

In one cubic metre of air (approximately 1.2 kg at 20 °C[182]), there is approximately 252,000 mg (21 %[27] of 1.2 kg) of molecular oxygen O_2. Even the OZONOS AC-1 PRO generates only 12 mg of ozone in one hour. That is 0.005% of the oxygen in a cubic metre of indoor air that is consumed in an hour!

67. Is an OZONOS which is switched on in the same room really harmless?

Yes! The **OZONOS AC-1 complies with the EN60335-2-65 standards**[165] **for household devices** with regard to the maximum ozone **concentration**. TÜV Süd also reviewed the test: "The test results[66] show that the product presented meets the requirements of the specified test requirements."[67] This means that the 0.05 ppm[165] are not exceeded even directly at the device under the unfavourable conditions in the test room. The OZONOS AC-1 is therefore harmless according to this regulation. Continuous operation **is not intended** for the **PLUS and PRO products**, they are used for intensive cleaning and should only remain switched on until odours etc. have disappeared.

If you use the OZONOS products in particularly **small and closed rooms**, for example in a small boat, a small toilet or a vehicle, you should **avoid staying in the location**. Staying in the room should also be avoided on intensive cleaning.

For dealing with these situations, see **Questions 70 to 73** on Pages 47 to 48. Basically, human beings are **protected by** their **sense of smell**.

**When you start to smell ozone more intensely,
simply switch off the OZONOS.**

Ozone can be smelled long before it is harmful to health. For the question of how ozone smells, see Question 63, Page 42.

68. Can pets be left in the room during application?

Yes. The **same rules apply as for human beings**. See Question 67, Page 45.

Why human beings and animals are better protected, see Question 41, Page 27.

69. How do my houseplants react to the ozone?

Yes. The **same rules apply as for human beings**. See Question 67, Page 45.

Plants are **much more robust** in the presence of ozone than human beings and animals. The EU Directive 2008/50/EC also specifies **limit values for protecting vegetation**. These are **many times higher** than those for human beings. As far as OZONOS is concerned, **that which is harmless to human beings should also be considered harmless to plants and animals.**[166]

During an **intensive cleaning,** it is **not necessary** to **remove** the **plants** from **the room**. However, animals and human beings are not to be allowed in the room.

Why human beings and animals are protected, see Question 41, Page 27.

OPERATION

The following questions only serve to supplement the already valid operating instructions.

70. Should rooms and cars, etc. be closed during treatment?

Yes, closed! No ozone is unnecessarily lost in closed rooms. In addition, **ozone decomposes much faster in drafts** and the effectiveness is reduced[26]. The treatment time is shorter in closed rooms.

It is the same **as with the air conditioning system in the car**. An **open window only helps at the beginning by venting once**, however, it should then be closed.

After the application of OZONOS, **ventilation can then take place**.

71. What influences the effectiveness of the OZONOS?

As a strong oxidising agent, ozone immediately reacts with many substances (odours) or particles (germs, etc.) in the air. Without a suitable reactant, over time, ozone completely decomposes back into oxygen[26]. If this premature decomposition is promoted, ozone or OZONOS is less effective. **The following environmental factors promote the decomposition** of ozone **and reduce** its **effectiveness**[26]:

- Higher **temperature**
- **Air movement**, drafts or fans, etc.
- Higher **humidity**

72. Should I wait to enter the room after the treatment?

With the **OZONOS AC-1, you can remain in the room all the time**. See on this, Question 67, Page 45.

According to the experience of the manufacturer, the OZONOS products, when **used in accordance** with the instructions, **cannot produce concentrations that immediately cause health damage when inhaled!** The most important points for rule-compliant application:

- Do not use OZONOS AC-1 PRO and PLUS in continuous operation

- Do not switch on the OZONOS AC-1 PRO and PLUS more than 15 minutes before cooking, roasting, etc.
- Keep away from the OZONOS AC-1 PRO and PLUS during operation
- Do not stay in the room during intensive cleaning and ventilate at the end
- Do not use OZONOS products in small rooms when you are in the room
- Switch off OZONOS products when you start to smell the ozone.

If you still have concerns, see Question 65, Page 43.

In **small rooms,** you should trust your own nose. **If the odour is unpleasant, wait or** ventilate, see Question 65, Page 43. For **boats and driver compartments**, you should then ventilate. The ozone concentration behaves similarly to the accumulated heat in a car that has heated up in the sun. **Opening the doors for a few minutes**, works wonders.

After intensive cleaning (OZONOS AC-1 PLUS and PRO): The measurements[66] under the unfavourable conditions according to the test procedure of the EN60335-2 standard[165] have shown that the ozone concentration halves in 62 minutes[181]. As a general **rule of thumb** with a very high level of safety, it can therefore be said that **one hour after switching off** the device **even small rooms can be safely** entered again.

See also Question 73, Page 48 and Question 63, Page 42.

73. What do you have to do if you smell the ozone?

Ozone can be **smelt even at low concentrations**[51,52], long before it could be harmful to health. See on this, Question 63, Page 42.

The following rule of thumb applies:

When you start to smell ozone more intensely,
simply switch off the OZONOS.

If you smell the ozone, the room air is clean in any case.

74. Is the device suitable for every type of room furnishing?

Yes. No cases **have been found in the literature** where the ozone concentrations generated by the OZONOS products have caused **damage to furniture, carpets, wallpaper or walls**.

The **only known group of materials** that cracks due to increased ozone values are **various rubber products** (earlier production car tires)[183]. The problem has

been solved in the meantime. No current case is known of damage that has been caused.

75. What is the effect of controlled living room ventilation?

None. Ozone air purifiers are already used in low-energy houses **with controlled domestic ventilation** (CDC)[184], but this is still the exception. A quicker **air exchange through shock ventilation** is **not provided for** in CDC and extractor hoods should also not be used. The cleaning of the room air is therefore essential. Here, an **OZONOS** product is the **perfect option**.

However, **the** OZONOS should **not be installed in front of the exhaust air openings**.

76. Is the effectiveness of the OZONOS guaranteed in every corner of the room?

Yes! With the built-in **fan**, **ozone** is **evenly** distributed in the room **over time**. Ozone goes wherever the air goes – even behind cupboards.

Ozone is slightly heavier than air and tends to sink. Since kitchen odours tend to rise due to the heat, **installation close to the ceiling increases effectiveness**. This also prevents children and pets from getting too close to the device.

MAINTENANCE

The following questions only serve to supplement the already valid operating instructions.

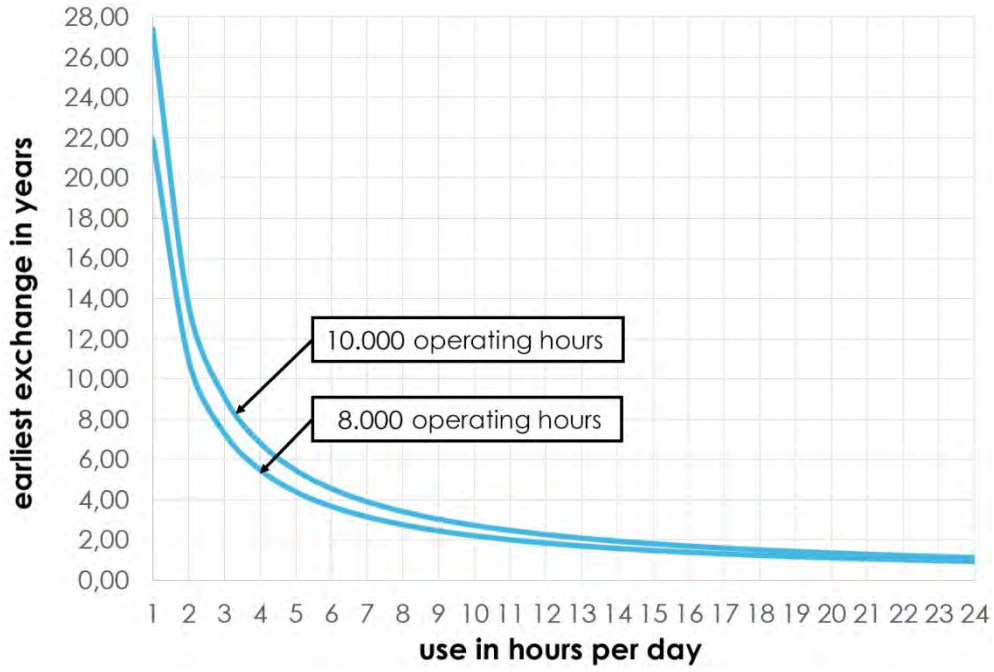
77. Do you have to replace a filter when using OZONOS products?

No, as the OZONOS products do not require a filter and are therefore completely **maintenance-free**. Only the UV-C lamp has to be replaced after some time. See Question 78, Page 50.

78. When do you have to replace or change the UV-C light?

The **UV-C light lasts 8,000 to 10,000 operating hours**. It produces less ozone after that time. The **effectiveness wears off** over **time**. **Replacement** is **necessary**. This fact can be recognised by the fact that the odour reduction, for example after cooking, is no longer as quick.

As an indication, the illustration below shows the **usual replacement intervals**. For example: If the OZONOS is operated for 5 hours a day, an exchange in approximately 4 years is to be expected, at the latest after approximately 5 years.



An old UV-C lamp generates less ozone than a new one. The achievable ozone concentrations are highest with new lamps. Ageing **lamps pose no health risk** with regard to ozone **concentration**. **The manufacturer also tests each UV-C lamp** before installation.

79. Can you replace the UV-C light yourself?

The manufacturer **generally** recommends that the **replacement be carried out by a specialist,** also because of the disposal. However, it is easy for a **skilled craftsperson** to replace the **UV-C light themselves**. Please follow the **operating instructions**!

The **UV-C lamps must not break**. They are filled with gases that should not be inhaled. It is the same as with neon lights. These **lamps should be disposed of**.

80. Can you clean the OZONOS?

Yes. The housing can be **gently wiped with a soft, clean, dry cloth**. Please follow the **operating instructions**!

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