Dear Sirs.
I would like to give a general statement to your questionnaire and will start with a short introduction of our company.

sterilAir AG (https://www.sterilair.com) is a Swiss born company providing UV disinfecting equipment since 1939 especially to the European market. With 2 subsidiaries in Germany (sterilAir GmbH) and Great Britain (sterilAir UK Ltd) and many distribution partners we are employing round about 30 highly skilled hygienic specialists and workers.

Since foundation of the company in 1939 (founded as W.A. Kohler and being transformed to W.A. Kohler AG in the 60ies of last century) the company always has had a strong focus on the food processing branch and especially high risk areas where microbial sensitive products get produced and/or stored. Product safety is granted especially by decontaminated air and package material which has lead to company's trade mark and name "sterilAir". During Corona crisis the demand for high level disinfection of air also has become aware to a much larger number of clients, but our main focus still keeps on beeing in the professional market of the food processing industry.
In our Swiss facility we maintain a highly specialised technical development laboratory as well as a microbiology laboratory (SII level) for research purposes. That means, we are developing and manufacturing products on our own and it is our vital interest to understand UVC technology by itself and to get the best solution for our clients. Thus we are are also strongly networked internationally on a scientific level, e.g. Agri-Food Canada (Dr. Tatiana Koutchma), ISI Food protection ApS Denmark (Dr. Dieter Elsser-Gravesen), Swiss Food Research (Dr. Peter Braun), MRI Max Rubner Institut (Germany), Züricher Hochschule für angewandte Wissenschaften zhaw (Switzerland), Forschungskreis Ernährungsindustrie FEI (Germany), Fachhochschule Weihenstephan (Germany), Karlsruher Institut für Technologie KIT (Germany), Hochschule Konstanz HTWG (Germany), and many, many others.
I hope this gives an impression about who we are and what we do.

Beside the much more well known UV water disinfection appliances there always has been a high amount of applications for surface and air disinfection purposes, especially in the food processing industry due to the ongoing demand for flawless food product quality and extended shelf live [1]. The number of clients in this branch is enormous and extensive. E.g. the largest meat processors can be found in our client list: Tönnies Fleisch, Danish Crown, Vion Group, BELL Group, MICARNA, SA GROUPE BIGARD, 2 Sisters Group, JBS, and many others.
But it is not only the meat processing facilities that have a high demand for high performance UV installations to grant a stable product quality either by UVGI (Ultra-Violet Germicidal Installations) for conveyor belt disinfection (https://www.sterilair.com/de/t2018.html), installations inside their air handling and humidification units (https://www.sterilair.com/de/aqt.html), UV emitters in combination with their HVAC systems (https://www.sterilair.com/de/esd.html) or very often by decentralised indoor air disinfecting devices (https://www.sterilair.com/de/d-serie.html). The use of ultraviolet disinfection technology is widely spread and all is done to keep air quality to the lowest germ count possible and thus to enhance product quality and shelf life.
Since the 20 years the trend towards convenience food got stronger and stronger, leading to an even higher demand for a high level product hygiene. It is not only some FERRERO sweets or semi finished bread rolls that need nearby sterile packaging and clean production environments, just imagine Dr. Oetker producing 1 million frozen pizzas every day in just a single factory. Or imagine all the fresh packed salads that you can buy in the supermarkets,

the EMI yoghurts that also have to be packed under nearby sterile conditions, all the ready to eat sausage and cheese slides that you use to cover the bread. Nobody wants mould in the package and you can't just spray some water peroxide or chlorine disinfectant solution on the packing foil or the product itself before wrapping it into the foil. This all is done under influence of high performant UV disinfecting devices.

As said, all of these products have to be produced under nearby sterile conditions and this is where our products are used. As a matter of fact the list of our customers with illustrious names is extensive: Dr. Oetker, Lieken, Hilcona, Kamps, Rügenwalder, Emi, Böklunder, Nestlé, Carl Kühne, Kraft Foods, Schwartau, 2 Sisters, Tulip, Ferrero, Chocolat Frey, Lindt & Sprüngli, Barilla, Aryzta, Warburtons, Coca Cola, Bimbo, FrieslandCampina ... just to name some of them. They all use and trust UVGI installations to get and to offer a stable food quality as well as a good shelf life being desired by consumers.
As a consequence we are seen and accepted as a reliable OEM partner for many internationally active companies that develop and offer high quality machines for the food processing market like MULTIVAC Sepp Haggenmüller SE & Co. KG, Kaak Nederland B.V., Handtmann Maschinenfabrik GmbH & Co. KG, König Maschinenges. m.b.H., Kronen GmbH, Heinen Freezing GmbH & Co KG, and many others. They all integrate Hg low pressure emitters in their machines to get the best possible hygienic solution for their clients.
And as all starts with a perfect air conditioning the number of companies integrating UV lamps in their HVAC products also is numerous: Güntner GmbH & Co KG, Seven-Air Gebr. Meyer AG, Hälg & Co. AG, Mountair AG, Klimatec GmbH, Thermofin GmbH, Island HVAC Systems Ltd, and many, many more.
It is imperative to understand, that UV air and surface disinfection is a widely accepted standard to gain perfect product quality. It is out of public awareness, but it is a very common technology in the food industry. UV gets used whenever substitute technologies like H2O2 disinfection, e-beam or gamma rays just can't be used.

But the challenge now is as follows: UV works after according to the dose principle. Comparable to a finger that slides through the flame of a candle, I am sure you will slide it fast enough. And as air velocity inside industrial applications is pretty high and microbial UV exposure in most of the cases is less than a second, germicidal UV energy has to be defined extremely high to be efficient. E.g. in case of a decentralised air re-circulating unit (https://www.sterilair.com/de/uvr-4k.html) the pure germicidal power has been proven to be at least 72W@254nm per unit to grant a satisfying mould spore reduction [2].

Even though microbes like Listeria, MRSA, EHEC, Legionella and since 2020 Corona is much more common and present in the media, there is a decisively higher focus on mould spore reduction in the food processing industry for different reasons. Saying this it is imperative to understand, that mould spores are ***much more*** UV resistant compared to the microbes named before. Generally spoken the needed range of D90 values (meaning the dose required for 90% disinfection of spores) is approximately 440-2'000 J/m^2 and by this at least 200 times higher compared to the well-known "media germs" [3]. Especially Latorre et al. tested the effectiveness of different wavelengths of the UV ranges in irradiation on mould types Cladosporium cladosporioides, C. herbarum, P. clavispora and Botrytis cinerea and found UVC in the range of 254nm is by far the most effective spectrum for spore disinfection. Results indicated zero survival of conidia (spores) at the highest UV dose of 1'100 J/m^2 [4].

To design and offer disinfecting devices that fulfil these needs from a technical as well as economical point of view based on current LED technology is utterly ***impossible!*** Moreover, pure physical limitations of LED technology indicate that necessary UVC intensities very

likely never can be reached by LED technology even with the most optimistic extrapolation of development. Reason is, deep-ultraviolet light-emitting diodes exhibit relatively low external quantum efficiencies because of properties intrinsic to aluminium-rich group III nitride materials. Meaning diode technology gets worse in efficiency the shorter the emitted wavelength has to be [5].
Most sophisticated UVC diodes of nowadays advertise an output performance of 80 mW @ 800 mA current (short peak under laboratory conditions, e.g. Luminus Devices Inc., Crystal IS or OSRAM Semiconductor), neglecting live span reduction due to this overheat design and missing long time stability in performance.
Just to show the difference: A standard Hg low pressure emitter offers a stable germicidal output of ~ 15'000 mW @ 165 mA (sterilAir lamp type UVC 2036-4N) and a high output Hg low pressure emitter can reach an output wattage of up to 100'000 mW (Heraeus Noblelight lamp type NNI 370/77 XL HR). This is a power increase of 1'250 times compared to the most powerful UVC LEDs being available on the market.

Beside the mould combat there also has been a strong scientific focus throughout the last two decades on examining the shelf life extension and quality improvement by highly intensive and direct UVC exposition of different foodstuff. A good summary of present work was done by the German Max Rubner Institute in 2010 showing the positive effects of UV exposition of up to 500 J/m^2 [6].

Even though our company has a strong focus on food production industry there are numerous other applications with a strong demand for high intensity UV ray sources. Here to name e.g. existing UV safety barriers inside air ducts/ HVAC systems of high-security laboratories, many standard microbial testing facilities and also hospitals. They all need reliable and safe disinfection of all known **and unknown** germs [7] [8]. To achieve the highest effect for decontamination inside air ducts there is a need for radial emitters, as systems for best efficiency have to be installed perpendicular to the air stream inside air ducts. These kind of grid installations cause highest efficiency, security and lowest air drag. They just can't be replaced by low emission LED arrays.

And especially in the fight against increasing MRSA (Methicillin resistant Staphylococcus aureus) problems in hospitals radial emitting high power emitters have been proven to be very effective [9]. The prohibition of these kind of high performance low-pressure emitters will cause a decisive setback in multipresent fight against all upcoming multi resistant microbes.

To sum it up: As a company dealing with UV disinfection devices for more but 80 years, we are always looking for superior and novel technologies to be ahead of our competitors whenever possible. Thus we are continuously evaluating and testing different technologies and try to optimize current process technologies. As a matter of fact we are known to low pressure technology, high and medium pressure emitters, flash light and Eximer lamps and novel UVC LED emitters.
1.
Non of the substitute technologies can outperform Hg low pressure emitter efficiency. Hg low pressure emitters provide an unbeaten efficiency of up to 46 %!
2.
Neither Eximer lamps nor LED emitters can reach the life span of Hg low pressure emitters. Useful life rate of Hg low pressure emitters is up to 18'000 hours (@ ~70% of initial output measured under laboratory conditions).
3.
Lowest LED price is said to be 0,10 $/ mWuvc, which is currently more but 100 times (!)

higher compared to the price level of a conventional Hg low pressure emitter. None of our clients is willing to pay a hygienic solution which gets 100 times more expensive!
4.
With an annual quantity of ~10'000 emitters/ year (before Corona crisis) and a very small amount of only Hg 5 mg/ lamp our total amount of mercury is 50g annually. Beside the very low quantity, mercury containing lamps are dismantled and the mercury is recycled.
5.
Current high performance UVC LEDs have a pretty low life span and are sealed units with their electronics and heat sink. They can't be replaced and have to be treated as electronic scrap, while Hg emitters can be replaced and recycled solely.

As a matter of fact Exemption No. 4(f) of RoHS Annex III should be requested at least until 2026 and beyond. We are very sceptical that there will be a substitute technology for Hg low pressure emitters within the next two decades. The current wording of the exemption: "Mercury in other discharge lamps for special purposes not specifically mentioned in this Annex" should therefore be retained unchanged.

[1] Koutchma, 2014 - Food Plant Safety UV Applications for Food and Nonfood Surfaces

[2] Schiffer, 2017 - Designing and validating a test system to determine the inactivation efficiency on airborne microorganisms in an industrial ultraviolet germicidal irradiation unit

[3] Kowalski, 2016 - UV Light for Mold Control in Indoor Medical Marijuana Gardens

[4] Latorre, 2012 - Germicidal effect of UV light on epiphytic fungi isolated from blueberry

[5] Kneissl, 2019 - The emergence and prospects of deep-ultraviolet light-emitting diode technologies

[6] Stahl, 2010 - Untersuchungen Auf dem Gebiet der UV-C-Behandlung von Rind-, Schweine-und Geflügelfleisch

[7] Kowalski, 2002 - Immune building systems technology

[8] Kowalski, 2009 - Ultraviolet Germicidal Irradiation Handbook, Chapter 2 Bioterrorism Defense

[9] Jelden, 2016 - Comparison of hospital room surface disinfection using a novel ultraviolet germicidal irradiation (UVGI) generator

Thank you for reading.

Freundliche Grüsse / Best regards

Martin Graupner
Chairman

Answer provided as is by Martin Graupner on behalf of SterilAir AG on the 13th of May 2021.